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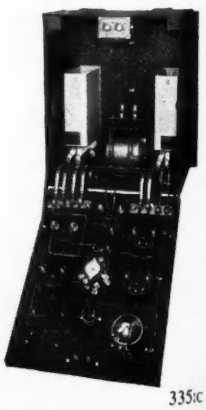

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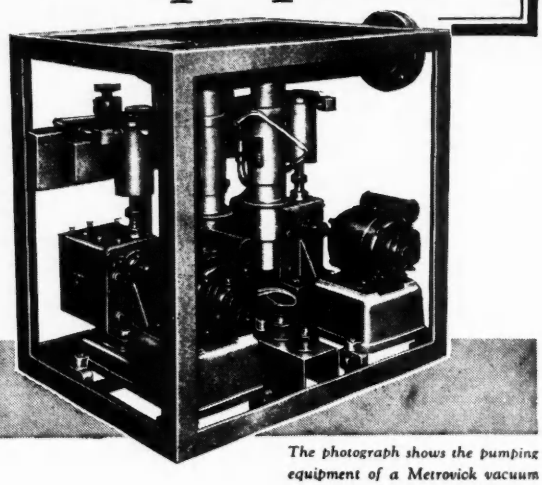

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Editor WILLIAM E. DICK, *B.Sc, F.L.S.* *Editorial Office* 244 High Holborn, WC1 Chancery 6518
Subscription, distribution and business communications to Jarrold & Sons Ltd, Norwich Norwich 25261
ADVERTISEMENT OFFICE Aldridge Press Ltd. 27 Chancery Lane, WC2 Holborn 8655

FEBRUARY 1954 VOLUME XV NUMBER 2

THE PROGRESS OF SCIENCE

SCIENCE AND THE PRESS

The lecture entitled "Science and the Press" which L. J. F. Brimble delivered to the Royal Society of Edinburgh on January 11 was both vigorous and wise, and everyone who is interested in this topic should read the full address.

Mr. Brimble can speak with great authority on this subject, firstly because he is one of *Nature*'s two joint editors (the other is A. J. V. Gale), and secondly because he is acquainted with all the science writers of Fleet Street and their work, one or two of whom enjoy his close friendship and appreciate his keen criticisms of their efforts.

His lecture contained some historical facts about *Nature*, the world's most famous science journal which came into existence in November 1869. It was born out of discussions which Sir Norman Lockyer, its first editor, had with Alexander Macmillan, founder of the great publishing house. Among those who supported the suggestion of starting a scientific weekly magazine were Sir Joseph Hooker, Archdeacon Hare, novelist and poet Charles Kingsley, and Dean Farrar, headmaster of Harrow and novelist.

Nature's second editor was Sir Richard Gregory, who was appointed assistant editor in 1893. Sir Richard succeeded to the editorial chair in 1919, and held control until his retirement in 1938. Since that year the editorial responsibilities have been shared by Mr. Brimble and Mr. Gale, who make a remarkably effective combination.

We agree wholeheartedly with the remark of Mr. Brimble that "it is not sufficiently realised by men of science in general what a great debt they owe to *Nature*'s publishers—Macmillan & Co. Ltd." The journal was initially launched solely for the advancement of science in spite of the fact that it was (and still is) privately owned by a business firm. It is quite possible, said Mr. Brimble, that had the first directors of that firm not been prepared solely in the interests of science (and with no hope of financial reward in the foreseeable future) to publish *Nature* at a financial loss for several decades, then *Nature* as we know it today would not exist.

It is quite true to say that in those days, and even today, the directors of Macmillan's never interfere with or attempt to control *Nature*'s policy. Mr. Brimble also explained how, in the interests of scientific integrity, not even the scientific books published by the same firm and under the same roof as *Nature* itself, receive any form of preferential treatment. "For example, I wonder if there is any Fellow of the Royal Society of Edinburgh who has had the cruel experience of editing an adversely critical review of one of his own books, to be published in his own journal, and has had to resist the temptation to blue-pencil what he thinks is unfair. That has happened to me in the case of two of my own books published by Macmillan's."

The lecturer deplored the haste with which some scientists rush into print. This tendency still exists, indeed "more often now than ever before some scientists, having submitted a communication for publication, eventually ask to withdraw it or to be allowed to modify it because they have either discovered an error or have since learnt that some of the work has been done elsewhere. This tendency is also revealed in the appalling state of corrected proofs received from some authors—sometimes peppered with corrections and changes which are anyhow very expensive to make."

Another shrewd point of Mr. Brimble's is worth quoting verbatim:

"*Rushing into print is also inspired by the bugbear of priority. For example, the request by an author that his communication should be treated as urgent because he has learnt that similar work is being done (usually in the United States) is now treated like the cry of 'Wolf! Wolf!' It is happening far too often. How refreshing it is when one team of workers, having heard that another is working along the same lines, gets into touch with the second group and arranges a joint communication!*"

Speaking of the overwhelming spate of scientific literature which makes it increasingly difficult for anyone to see "the wood for the trees", Mr. Brimble said that much of the detail published in research papers is of limited interest and value. He suggested that scientists might well consider

publishing only the main points of their research and filing the rest for possible future reference. He cited Lord Rutherford as saying that when writing a letter to *Nature* if you cannot say all that is really necessary in 500 words or less, then something is wrong. "If every scientist throughout the world believed this and took it to heart, then I can visualise even *Nature* having no time-lag in publication at all. It is significant that though *Nature* frequently returns a communication to an author with a request that it should be reduced to two-thirds or one-half its present length, I can only recall about two or three instances in the whole of my well-nigh quarter of a century connexion with *Nature* an author replying that he could not cut his communication."

He invited scientists to ask themselves the following questions before submitting a communication for publication:

(1) *Are you sure you have said what you want to say?*
(2) *Have you said it in the minimum number of words?*
(3) *Is it worth saying at all?*

He thought that too many scientists, especially younger ones, seem to assume the value of a scientific paper varies directly as its length. "I would strongly urge that men of science thoroughly train themselves to keep their mouths shut and their pens dry until they know the facts or are sure of what they wish to say. Surely we should make it our business to see that our scientifically acquired knowledge is rightly stated if it is to be rightly used!"

Mr. Brimble devoted a large part of his address to the coverage of science by the popular Press. He called for a more generous attitude to the scientific expositor, who has rarely received from his scientific confrères the honour that is his due. "It is very important that the expositors and interpreters of science as represented by our science writers should be sure of the appreciation and support of their professional colleagues to which they are entitled."

He referred to the time when a scientist who dared to write popular books or articles in the daily newspapers was considered by his more aloof colleagues to be beyond the pale. "It seemed to be tacitly assumed that if a man could write well, then his researches were second-rate. This never was, and neither is the case. Many of our leading men of science do not even know whether they can write for a lay public, because they have never tried to do so. If only more of them would, then we should be surer than ever of the great scientific truths reaching all men and women. There are, however, many scientists who are so beset with their own jargon that interpretation to the wider field is virtually impossible. This side of the question goes back, like many other problems, to that of education."

He then said that many men of science still do not take seriously enough their duties to the Press. Admittedly in the past the Press has been far from blameless, but he suggested that it is possible that many scientists still think of those past failings without being aware of the efforts which have comparatively recently been made by the Press and the professional science writers to rectify matters. Editors are now certainly more sympathetic towards science, and even desirous of giving science the publicity which it not only deserves, but also should have if we are to succeed finally in counteracting that almost fanatic antagonism towards science which one still meets in far too many quarters.

"Today we see the majority of our national newspapers having science writers or science editors on their staffs. Some of these men and women have had an academic training in science; all of them are expert in scientific interpretation—a great improvement on the position of less than twenty years ago."

The lecturer expressed the view that too many scientists still tend to shun the newspaper Press, perhaps fearing misrepresentation. He did not think there was much need for this concern nowadays, and he was sure that the best way to obviate it, anyhow, was to see that there is closer collaboration between scientists and pressmen.

Mr. Brimble continued: *No man of science is justified in shunning our present-day special science writers and reporters. Most of them are experienced men doing an excellent though very difficult job of work. It is their responsibility to interpret accurately to the general public the scientific findings of the specialist. It is their job to nose out the news. It is also their responsibility to ensure accurate presentation, so they look to the scientist for help. Reporters and science writers should be treated as gentlemen, not as sleuths who must be avoided or even snubbed. Let us hear less about scientists being inaccessible, unintelligible and uncooperative. A wise scientist, active in the field of research, will get to know his reporters and make friends with them. It is not only their duty to themselves and their fellow men, but also to science itself, for while the lay public who read newspapers every day, but never read science journals, remain either ill- or wrongly-informed about things scientific, we shall continue to hear the complaint that science is the cause of many of the world's ills and that scientists should be put into chains.*

He criticised the newspapers for their reluctance to admit errors, except under legal pressure. They imagine that they would lose caste, and perhaps custom, by so doing, but he believed, provided it does not happen too often (and it does not), that the correction of an error, especially in science news, would inspire greater faith among readers. "I shudder to think what would eventually happen to *Nature* if we refused to publish an erratum if one is necessary."

THE PILTDOWN STORY: A REGRETTABLE INCIDENT

We believe Mr. Brimble has rendered a public service by strongly criticising the way in which the news about the Piltdown fraud was released. He stated quite categorically that *The Times* report of November 21, 1953, was no scoop in the Fleet Street sense of the word. This is quite correct, as newspapermen know to their cost! The story was delivered to *The Times* like the head of John the Baptist, on a charger. The other newspapers never had a chance. (It may interest readers to know that no details of this story were ever received at DISCOVERY's office, and in fact we had to purchase a copy of the relevant Natural History Museum bulletin on November 23, which necessitated a visit to the museum since the bulletin was not on sale at

H.M. Stationery Office.) It is a matter for extreme regret, as Mr. Brimble pointed out, that the Piltdown story was given exclusively to *The Times*. *Nature*'s editors were told, in advance and *confidentially*, that although the paper describing the Piltdown research was already in print in the Natural History Museum bulletin the news was being sent exclusively to *The Times*. A copy of that number of the bulletin was left at *Nature*'s office, and no doubt one was in the hands of *The Times*.

Mr. Brimble said that *Nature* is still very concerned that a group of scientists attached to two great institutions which are largely supported by State funds, namely the Natural History Museum and the University of Oxford, should have acted in this way. "It was not fair to the British Press, and it was not fair to the British reading public. The obvious way to treat the announcement would have been either to wait until the relevant paper appeared in the museum bulletin and had been published there, or to give an entirely open press conference." There was no press conference, and here, therefore, was "a case of favouritism by scientists when selecting their means of publication among the general newspaper Press". Many in Fleet Street, and no doubt elsewhere, were annoyed by this incident, said the speaker, a fact which we can certainly confirm.

Final comment by Mr. Brimble on this unfortunate incident, which represents a sin against the principle of public relations which such public institutions as the Natural History Museum are duty-bound to maintain because they are financed by the taxpayers, was this:

I believe that he who pays the piper is entitled to call the tune, and in this case the institutions concerned dance to the piping mainly of the taxpayer, which includes all newspapers; not just one. I am not aware of other individual scientists or teams of scientists whose work is supported by public funds having committed themselves to giving exclusive news to any one newspaper, but if such scientists exist, I trust they will reconsider the practice. Our newspaper Press is now far more sympathetic towards science, and it is for men of science themselves to encourage this attitude.

PATENTS ON PLANTS

In Britain patents cannot be obtained on new varieties of plants, nor on new species introduced from abroad; as one gardening paper puts it, "the policy is that the introduction of living things like plants shall not be given patent monopoly".

The recent unsuccessful attempt of Wheatcroft, the Midlands rose-grower, to get certain rose varieties registered under the Trade Marks Act has not only provided patent lawyers with a very controversial talking point, but it has also aroused interest in the system of patent protection which can be obtained in some countries (e.g. Holland and the U.S.A.) for new varieties.

The Wheatcroft claim failed because varieties registered with the National Rose Society cannot also enjoy registration under the Trade Marks Act. The case is rather similar, so far as the legal principle is concerned, to any attempt to make the word 'aspirin' a registered trade mark after that word had gained general acceptance through publication in a chemical journal.

Illustration from the American patent specification for the Thornless Blackberry which was bred in Britain.

Opinion in Britain is divided as to whether patent protection for plant varieties would be of general benefit. The case for it has been well expressed by *Amateur Gardening* in these words:

Where the patent law does exist, these two results follow: first, satisfactory specimens of the new variety are made available for buyers (for the original raiser will in his own interest licence only suitably qualified growers); and second, there is a reasonable financial return to the successful raiser for his outlay of labour and money.

It may be noted that had the Wheatcroft claim for registration of trade marks been upheld, then the firm would have had the equivalent effect of patent protection on its varieties, and *that protection would have been everlasting*, instead of for the limited period which applies to patented inventions.

The patenting of plants in the U.S.A. became possible with the passing of the Plant Patent Act of 1930. The patentable characteristics of plants include such things as unusual habits of growth, relative immunity from disease,

resistance to cold or heat; colour of flower, leaf, fruit or stem; productivity, including ever-bearing qualities in fruits; storage ability of fruit; perfume, form and other flower qualities; and ease of vegetative reproduction. No patent can be issued under U.S. law on seeds or on any plants that reproduce only by seeds. (A useful article on the U.S. system of plant patents can be found in *The National Geographic Magazine*, March 1948.)

It is interesting to see the extent to which the Americans have taken advantage of the 1930 Act. According to the article cited above, over 750 plant patents had been granted by 1948. About half have been on new rose varieties. About 75% of some 175 patents on edible plants and products covered fruits of the family Rosaceae—e.g. apples, pears, plums, cherries and the like. A few patents have been granted for new plants bred in Britain, such as the Thornless Blackberry developed at John Innes Horticultural Institution.

THE FLIGHT OF INSECTS

Physiological experiments with flying insects have been yielding some very interesting results, and much new information has been published in *The Transactions of the Royal Entomological Society* (1953, Vol. 104, Pt. 8) by Prof. B. Hocking, the entomologist of Alberta University. He has worked with four mosquito species, four species of Tabanid Flies and two species of Simuliids ('Black Flies'), and he has also made some additional confirmatory observations on the Honey Bee and the Fruit Fly (*Drosophila*).

The energy reserves present in the experimental insects were assessed by examining histologically the fat and glycogen content of their bodies; by comparing the average weight of a specific kind of insect with the average weight of specimens of that insect which had been flown 'to exhaustion'; and finally by measuring the distance flown by newly emerged specimens.

The actual energy which is directly available to provide the power for insect flight is markedly less than the supply of chemical energy theoretically available in the food the insect eats; this is due to the fact that the insect is not 100% efficient when it comes to digesting the food and using the digested food as a source of energy to support muscular activity upon which insect flight depends. (Some of the ingested food is used, of course, for purposes other than energy production—namely the building of body tissues and the maintenance and repair of those tissues.)

The food reserves within the body tissues were found to be largest in the mosquitoes and smallest in the black flies; but in all cases they proved to be much smaller in proportion to the size of the insect than those found in *Drosophila* by Dr. Wigglesworth.

After initial experiments in which the insect was suspended from a cotton thread, a special 'flying mill' was built by Professor Hocking for his tests on flying insects. The mill consists essentially of a long arm mounted on a revolving hub. The insect is attached to a further shorter arm which is fixed to the top of this long finger. The tip of this shorter finger, to which the insect is attached by a small blob of wax, points at an angle of 90 degrees to that of the long finger. Thus the insect attached to the mill pulls round the longer finger in a clockwise sweep as it flies. Both fingers are carefully balanced prior to the attachment of the insect so that it supports only its own weight while flying and turning the mill. The frictional and aerodynamic drag of the mill at different speeds are calculated before the experiments so that the apparent performance of the insect can be adjusted so as to give its real performance.

The revolutions of the mill finger are counted by a photo-electric cell, and a 'landing mushroom' (consisting of a plastic disc 4 centimetres in diameter) is provided at one point of the circular orbit of the finger. This landing plate is brought into use as soon as the insect is seen to cease beating its wings, being swung upwards so as to come into the flight path of the insect which then alights on it when next it reaches that point.

In Professor Hocking's experiments the insect was considered 'exhausted' when it failed to fly continuously for fifteen seconds on three successive occasions after the landing disc was withdrawn. Rest periods of one minute were allowed during the experimental flights.

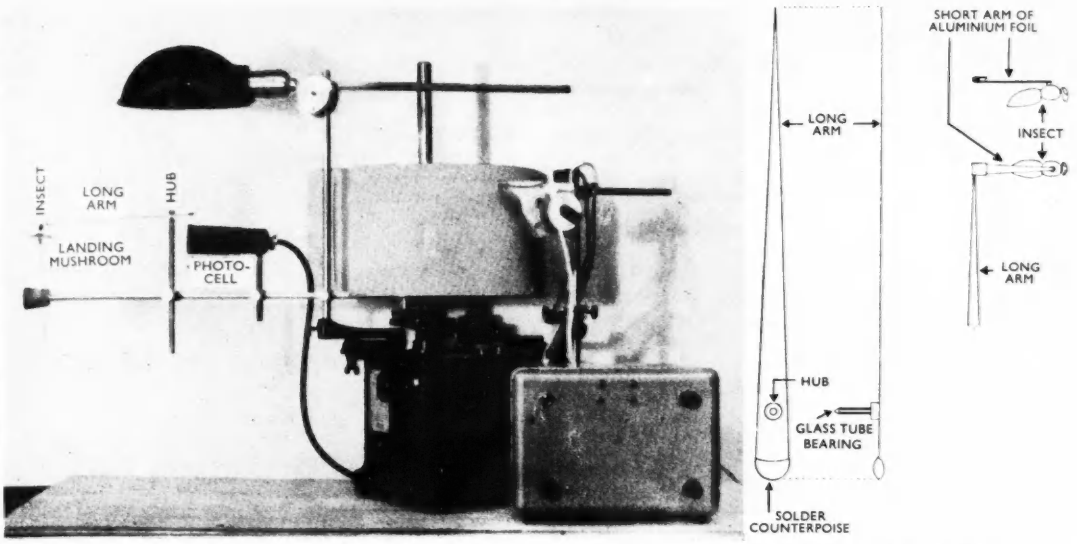
In each species the average weight of the insects after they had been flown to exhaustion was less than that of foragers caught in the field after the weight of the contents of their crops had been subtracted. This difference in weight was due to the quantity of glycogen reserves in the body tissues used up by the effort of flying. When these reserves were calculated by this 'performance' technique of weighing exhausted and unexhausted, but empty, insects, the figures showed a marked discrepancy with those obtained by the histological analysis, especially in the case of the larger species.

This seemed to be due to the fact that the larger species which have a lower surface bulk ratio need to evaporate more water (in order to keep cool while flying) than do the smaller insects.

Many experiments were undertaken with the flight mill, in most of which the insects were fed on measured quantities of glucose. The insect's performance during each flight was automatically recorded on a revolving drum. In nearly all cases there was a marked difference between the maximum cruising speed and the maximum speed achieved over a short distance. Figures of flight endurance and range obtained from the mill approximated closely to those which were calculated on the basis of the basic weight, load, aerodynamic drag and the energy available.

Thus the calculated maximum range of *Tabanus affinis* proved to be 99 kilometres, while the performance of this insect in the flying mill gave a similar figure—91 kilometres. It is therefore not surprising to find a butterfly like the Monarch can reach islands 1000 miles away from its place of origin; according to Professor Hocking's calculations for a hypothetical butterfly of this type it should have a flight range of about 1050 kilometres when cruising at a speed of 250 centimetres per second. Only a slight following wind would be necessary to help it achieve a thousand-mile journey.

A large amount of data was also obtained by Professor Hocking by studying the frequency of wing beat with the aid of a smoked kymograph drum, and by studying the aerodynamic properties and performance of the insects in a straight-flow and a return-flow wind tunnel. Both wind tunnels were made from two aluminium tubes (6 in.



(*Left*) Photograph of Professor Hocking's flight mill; note the landing mushroom on which the test insect rests. (*Right*) Diagrams showing the mechanical details of the long arm of the flight mill, and the method of mounting the insect.

diameter) separated by a 9-in. long working section made of transparent plastic. The air flow for these two tunnels was produced by the suction of a small centrifugal blower worked by a ¼ h.p. motor.

Tests with dead wingless insects in the wind tunnels showed that their bodies exerted considerable lifting power when the insect was flying at maximum speed, when the lift was equivalent to about a third of the body weight with the body at the normal flight angle.

When the flight angle of the body was increased beyond that of natural flight, the lift was increased; whereas when the flight angle was decreased below the natural angle, the lift exerted by the body surface gradually decreased to zero. These measurements show that the aerofoil action of the insect's body plays no inconsiderable part in maintaining it in the air. The rest of the lift is provided by the movement of the wings and the force they exert on the air. Some measure of the amount of work done by the wings can be obtained from the fact that two of the larger species were found to pass nearly two litres of air through their wings each second.

Despite the aid obtained from the lifting action of their bodies, the power required to maintain the insects in the air ranged from 11 ergs per second per milligram of body weight in the smaller species, to 38 ergs per second per milligram in the case of the larger species. Moreover, despite the great efficiency of continuous energy transformation found in insect wing muscles (between 16 and 40 times that found in human muscles), the power outputs of these muscles are only about 3 to 6 times those of human muscles. It is here, suggests Professor Hocking, that the greatest inefficiency of the insect flying machine is to be found. Aerodynamically it is efficient, but in power production it is relatively inefficient.

One interesting suggestion made by Professor Hocking is that insects migrating over water do not settle on the sea, but continue flying steadily over it, because the waves appear to move in the same direction as the wind and at an only slightly lesser speed. As a result the insects never receive the impression that they are being driven backwards by the wind even when this is in fact happening, because the waves will always be driven back faster than the insect, and the impression of being driven back is a necessary stimulus to landing. His final conclusion on the range and speed of flight of insects is that the maximum range of an insect flying continuously without feeding and in still air is about 1000 kilometres, while the "maximum continuous speed of flight of any living insect" is about 12 metres per second, although short bursts of up to 16 metres per second may be possible.

LINNEUS AND HIS CULTURED PEARLS

According to the *Sunday Times*, the Japanese have just unveiled a statue to Kokichi Mikimoto, the Japanese 'pearl king', who is credited with having discovered in 1890 how to produce artificial pearls. Yet the records show quite clearly that the great Linneus (1707–78) discovered how to perform this trick many years before Mikimoto. Some of the pearls he made can be seen at the Linnean Society in London.

In 1732 he visited the best known pearl fishery in Luleå, Lappmark. He recognised that the pearl "in the mussel is not natural, but a disease". Writing about this phenomenon later, he remarked, "He who could cause this illness in a mussel would also be able to make it produce pearls. If one could make each mussel artificially produce pearls, nothing could be more profitable."

The idea was put up to the State Chamber of Commerce

in 1749, but they rejected it. Linneus approached them a second time, in 1761, saying at the beginning of his long and very interesting petition that "I know of no one who can make pearls". (Though apparently he had already read an account of how the Chinese had discovered the art of producing cultured pearls.) He stated that he had found the key after experiments with sea-mussels, which, however, yielded pearls inferior in lustre to those obtained from freshwater mussels at Purkijaur. The upshot was that in July 1761 he attended a committee meeting in Stockholm, and displayed his cultured pearls after all those present had been sworn to secrecy. Linneus' method depended on the insertion of a silver wire to which he attached a tiny ball of plaster or limestone. The thread was made fast to the mussel shell, and after five or six years the mussel secreted a pearl the size of a pea. The committee was much impressed, and passed a resolution describing this discovery as "the greatest increase to natural history of the century". The Chamber of Commerce awarded him £450 and the right to relinquish his process to his son or anyone else who deserved it. The technique of making pearls was to be kept secret. Soon afterwards the Swedish Parliament allowed the process to be leased to a Göttenburg merchant for the sum of £450. The money was especially welcome for at this particular time Linneus was in financial difficulties through the purchase of the famous estate at Hammarby.

It is thus quite clear that Linneus anticipated Mikimoto by a matter of 140 years. It would be interesting to find out when the Chinese discovered the art of inducing shellfish to secrete pearls to order. Perhaps our readers could help to establish the true origin of cultured pearls.

3-D CHEMISTRY

Just over a hundred years ago Pasteur contributed a major plank to the jumping-off board which led to the visualisation of the three-dimensional structure of molecules. The importance of his contribution is discussed in a delightful essay by Prof. J. D. Bernal in his latest book, *Science and Industry in the Nineteenth Century* (published by Routledge and Kegan Paul, 12*s*. 6*d*.).

The geometrical law of crystallisation had been established many years before by the Frenchman, René Just Haüy (1743–1822), who also discovered the phenomenon of pyro-electricity. Another link in the story was provided by the work of Herschel at Cambridge, who observed that with quartz one type of crystal turned the plane of polarisation to the right, whereas the other type of crystal turned the plane to the left. With great prescience he realised the importance of this discovery. He said (in 1822) that "It may lead us to pay a minuter attention to those seemingly capricious truncations on the edges and angles of crystals . . . it is not improbable that an accurate examination of them may afford us evidence of the operation of forces of which we have at present no suspicion."

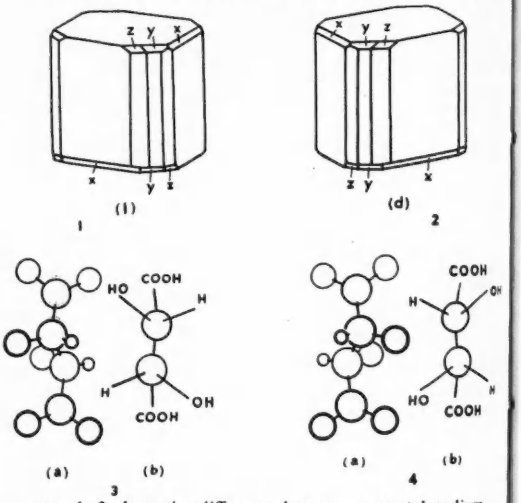
A minuter examination of the "seemingly capricious truncations" of tartrate crystals was made by Pasteur. He found that the paratartrate of soda and ammonia (sodium ammonium racemate) contained two different kinds of crystals. He sorted out eight grams of this salt into two piles, one containing 'right-handed' crystals and the other containing 'left-handed' crystals. The two kinds of crystals gave optical rotation in opposite directions when they were dissolved in water and examined in the polaroscope. Thus it was that Pasteur, *on one and the same day*, achieved two major discoveries:

1. First, he demonstrated the difference of form between crystals of the double tartrate of ammonia and soda, and crystals of the double paratartrate of soda and ammonia.

2. He not only recognised the two enantiomorphic forms of a compound, sodium ammonium racemate or paratartrate; he also succeeded in separating them.

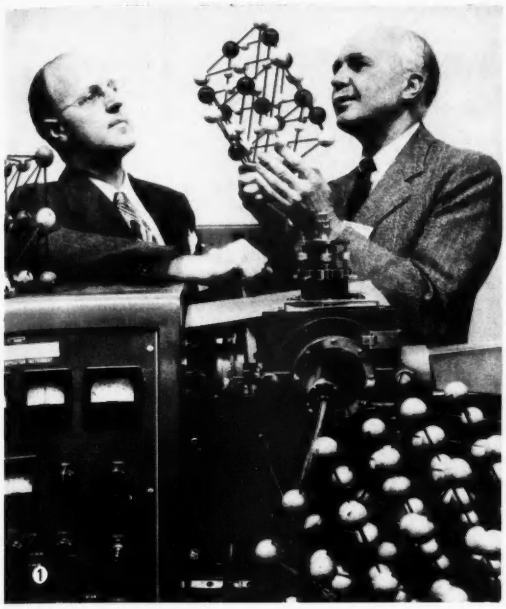
Thus Pasteur established the principle of molecular asymmetry. These were no random, isolated observations. They were the kind of facts which 'the prepared mind' of Pasteur was attuned to notice because they fitted in with the general tenor of his thinking in this field. His interest in physical methods of investigating chemical substances was based on his reading of the work of men like Mitscherlich. Here is what he said about the crystallographic line of thought which led him to the important discoveries connected with the tartrates: referring to the crystallographers' method, he said, "It consists above all of not altering the substance and of investigating scrupulously the substance, its properties as an intact unit, notably those which are most directly dependent on the mode of its internal arrangement. And as certain physical characteristics, such as the crystalline form, or the effects of changes imposed on light when it passed through crystalline substances or solutions, must play the biggest part, this method of proceeding can be called the physical method."

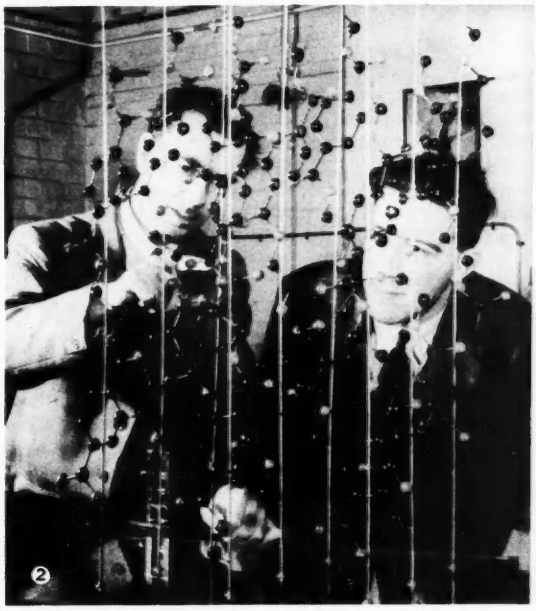
The discovery of molecular asymmetry marked the

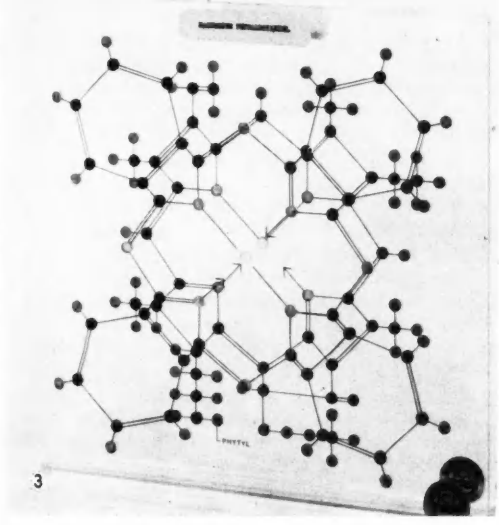


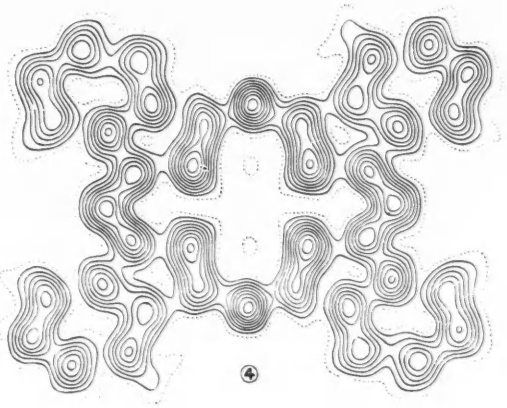
FIGS. 1–2 show the difference between a crystal sodium potassium l-tartrate and a crystal of sodium potassium d-tartrate. Pasteur succeeded in separating the two different kinds of crystal from the racemate. The only difference is in the position of the minute hemihedral faces x, y and z in the figures.

FIGS. 3–4(*a*) represent the actual configurations of the tartaric acid ions in the corresponding salts as determined by Bijvoet; they are mirror images of each other, a point which is also to be noticed in the crystals (FIGS. 1–2). FIGS. 3–4(*b*) are the conventional designations of the ions as given in ordinary chemical text-books.









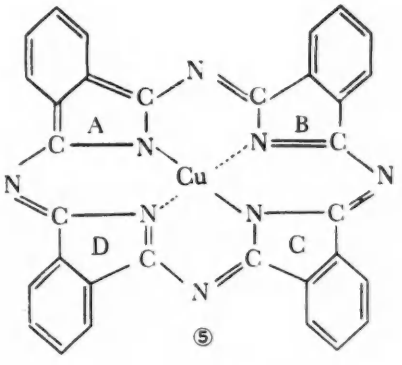


FIG. 1. Pioneer of X-ray crystallography, Sir Lawrence Bragg, seen standing behind a piece of electron-diffraction equipment in the General Electric Company's research laboratory in Schenectady, with Dr. C. G. Suits (G.E.C.'s director of research). The Braggs, father and son, were awarded a Nobel Prize in 1915 for "their merits in the study of crystal structure by means of X-rays": Lawrence Bragg was then only 25 years old. FIG. 2. 3-D models like this model showing chains of Terylene molecules are commonly constructed by chemists concerned with problems of molecular structure. FIGS. 3–5. The phthalocyanines, which are a recently discovered group of coloured substances with chemical similarities to the two common natural pigments, chlorophyll and haemin (the red colouring matter in blood), are important commercially in the dyestuffs trade. Readers will undoubtedly be familiar with one of them—Monastral Blue, which is the blue of the cover of 'Pelican' books, for example. FIG. 3. Model of molecule of magnesium phthalocyanine. FIG. 4. X-ray shadow picture of phthalocyanine molecule. FIG. 5. Molecule of copper phthalocyanine. *I.C.I. pictures.*

beginning of a great new era. Pasteur spent years working up this idea. For example, he developed a new method of separating the enantiomorphic components, that of crystallising their salts with an active acid or base, thus giving the two forms different physical properties.

He also developed a purely biological method of separation: "This was to turn him away completely from the career of combined physicist, chemist and crystallographer in which he had already made himself the greatest adept, only to embark on another, that of bacteriology with results which eclipsed all his previous work." He worked with a species of blue-green mould (*Penicillium*). On a mixture of paratartaric acid, the mould grew and the *l*-tartaric acid appeared. Wrote Pasteur, "These experiments bear witness to the profound line of demarcation between the mineral and organic worlds, since to imitate some fact in nature, that is to prepare a right-handed or left-handed compound, we are constrained to have recourse to a quite special type of intervention, the action of asymmetry . . . life is dominated by asymmetric actions of which we feel the enveloping and cosmic influence. Life is the germ and the germ is life. Now who could say what would be the *future* of germs if we could replace in these germs the immediate principles—albumen, cellulose, etc., etc.—by their inverse asymmetric principles? The solution would consist on one side in the discovery of spontaneous generation if such a thing should be in our power, on the other side if the formation of asymmetrical products by the help of elements—carbon, hydrogen, nitrogen, sulphur, phosphorus—if in their movements these simple bodies could be dominated, at the moment of combination, by asymmetric forces." Thus it is seen how Pasteur linked his thoughts on life and fermentation with the idea of molecular symmetry.

Pasteur's work eventually linked up with Kekulé's ideas on valency. Kekulé spoke of the tetrahedral carbon atom for the first time in 1859, but he did not associate it at all with molecular asymmetry or with the effects discovered by Pasteur. The reason, as Bernal rightly says, was that 19th-century chemists with the exception of Pasteur thought in two dimensions, not in three—they thought on paper and not in space, a mistake which many schoolboys are unfortunately forced to repeat today in their elementary organic chemistry lessons through faulty text-books and faulty teaching. Kekulé's model of the carbon atom was not a pyramid but a sausage which he denoted thus:

It was the Dutchman van't Hoff who developed space formulae giving an effective picture of the three-dimensional arrangement of the atoms within organic molecules.

Actually one finds that Pasteur had a shrewd idea about molecular structure. After he had established the existence of four isomeric forms of tartaric acid, he posed the following question: "*Are the atoms of the dextro-acid grouped in spirals of a dextro-gyrate helix, or placed at the summit of an irregular tetrahedron?*" Thus we see that Pasteur was near to solving the puzzle, but fourteen more years were to elapse before van't Hoff and Le Bel provided almost simultaneously a thoroughly satisfactory explanation of this phenomenon of stereo-isomerism.

The crystallographic work of Pasteur opened up other interesting lines of research. The French followed it up and developed the mathematics of crystallography, which led on to Pierre Curie's work and his discovery of the piezo-electricity of quartz (1880). Then we get the idea of a crystal lattice linking up with radiation physics and the discovery of X-rays: this yielded the discovery of von Laue and Knipping, so rapidly exploited by the Braggs as a means of working out the atomic structure of crystals. X-ray crystal analysis has proved a very powerful tool indeed. It is interesting to note that this has established the exact asymmetric characters of the tartrates Pasteur worked with: in this way Parry of Bernal's laboratory determined in 1949 the structure of racemic acid—the origin of the whole dispute which gave rise to Pasteur's investigations. The crowning achievement of crystal physics was the work of Bijvoet, who achieved in 1951 the apparently impossible task of determining the particular arrangement of normal and tartaric acid.

SCIENCE MASTERS

Without any doubt the organisation which best looks after the interests of the science and mathematics masters in Britain is the Incorporated Association of Assistant Masters. This organisation generally adopts a line of enlightened self-interest, and this fairly describes the general policy which was approved at the annual council meeting held in Buxton at the turn of the year.

One important resolution (drawn up by the A.M.A.'s Executive Committee) which was passed read as follows:

"This Council records its conviction that:

(*a*) the low maximum salary offered to teachers is the largest single factor deterring Science and Mathematics graduates from entering the teaching profession;

(*b*) the proposal to deal with the problem of Science and Mathematics teachers through the Special Allowances scheme is unsatisfactory on professional grounds;

(*c*) the solution of the problem of the supply of Science and Mathematics teachers can only come by raising the maximum salaries and status of all teachers to such a level as will make teaching a genuine profession."

Another Executive Committee resolution approved by the council meeting expressed disfavour of

"any attempt to mitigate the shortage of Science and Mathematics teachers in Grammar Schools by the introduction of short courses of training open to non-graduates in these subjects or by any other reduction in the standards required for status as a qualified teacher, and further reiterates its view that the teachers of these subjects in Grammar Schools should be graduates with professional training."

The Executive Committee put before the meeting a graded salary scale, which can be summarised as follows:

Grade I.—£800 rising by £30 a year to £1250.
For all *teachers in charge of a department, preparing pupils at A.L. in the G.C.E. (or equivalent exam).*

Grade II.—£700 rising by £30 a year to £1150.
For all *teachers who share in preparing pupils at A.L. in the G.C.E. (or equivalent exam).*

Grade III.—£600 rising by £30 a year to £1050.
For all *teachers concerned with pupils from eleven plus preparing for O.L. in the G.C.E. (or equivalent exam).*

Grade IV.—£450 rising by £30 a year to £900.
For all *teachers in all types of school not included in the above grades.*

A GIANT OF U.S. SCIENCE

R. A. MILLIKAN: 1868-1953

WILLIAM E. DICK

Just before last Christmas—December 19 to be exact, Robert Andrews Millikan died in San Marino, California, at the age of 85. In Britain he is remembered chiefly for his classic and elegant determination of the charge on isolated electrons, but in America he will be remembered for his many other activities besides research. His life spanned the period in which the educational structure concerned with science and technology was built up in the U.S.A. practically from ground level. A first-rate research worker, he was a man of whom it could truly be said, "and gladly would he learn, and gladly teach". His initial contribution to the teaching profession was as an instructor in physics at an American college while still an undergraduate. After taking his degree at Oberlin College, he went to Columbia University where he took his Ph.D. In 1896 he joined Michelson, the first American to win a Nobel Prize (1907), as an assistant in the physics department of Chicago University. He remained at Chicago for the next twenty-five years, being professor from 1910 to 1921.

In the latter year he became director of the Norman Bridge physics laboratory and chairman of the executive council of "Caltech"—the California Institute of Technology at Pasadena, which is the Pacific coast's counterpart of M.I.T. and a key centre for research and teaching in technology. During the period 1921–46 he rendered services of inestimable value to "Caltech" in particular and to the U.S.A. as a whole.

Prior to Millikan and his contemporaries, America had few scientists. Benjamin Franklin (1706–90) was an isolated phenomenon in the early days of the American nation, and had relatively little influence on the subsequent development of scientific research and teaching in America, though he took a hand in the founding of the American Philosophical Society in Philadelphia (1769). Societies such as this encouraged scientific research and helped to establish strong links with European men of science, notably Lavoisier, Linneus, Buffon and Condorcet. The French ties were particularly strong, and indeed an ambitious attempt was made to create an Académie des États-Unis de l'Amérique in Richmond, Virginia, which was intended to replicate the French Academy but which never materialised owing to the withdrawal of French aid when the Revolution began in 1789. On the other hand the American Academy of Arts and Sciences of Boston, which received its charter in 1780, flourished exceedingly, and not unexpectedly since its early membership included such influential men as George Washington, John Adams (Washington's presidential successor) Thomas Jefferson, Benjamin Franklin and David Rittenhouse. 1818 saw the appearance of the first number of Benjamin Silliman's *American Journal of Science*, (generally known as *Silliman's Journal*): this "became the leading scientific journal in America for several decades and still holds a prominent place among such periodicals" (R. S. Bates, 1946).

One science, chemistry, got away to a flying start in America, due to the fact that the Chemical Society of Philadelphia was established as early as 1792. (This was virtually the world's first chemical society.) Other sciences were less fortunate; geology, for instance, to judge from this quotation:

"About the time when Mr. [Benjamin] Silliman was appointed a professor (1804), the entire mineralogical and geological collection of Yale College was transported to Philadelphia in one small box, that the specimens might be named by Dr. Adam Seybert, then fresh from Werner's School at Freiberg, the only man in this country who could be regarded as a mineralogist scientifically trained."

Physics was relatively a laggard science, and indeed it was not until 1899 that the American Physical Society was organised. The outstanding physicist in the first half of the 19th century was Joseph Henry (1797–1878), the American counterpart of Faraday, who began his career as a watchmakers' apprentice and ended up as the first director of the Smithsonian Institution, after serving as Lincoln's chief scientific adviser during the Civil War of 1861–65. Another native genius was Willard Gibbs (1839–1903).

To set the scientific scene it is vital to realise that there were few scientists teaching or researching in American universities. As Dr. R. S. Bates says, "Most American scientists in the first half of the 19th century did not find their careers as instructors in science in the colleges, but rather they either were amateur investigators or were employed in the service of the government."

Such was the academic situation when Millikan was born. His birthplace was in the little midwest town of Morrison, Illinois, and the date was March 22, 1868. Not three years had elapsed since the long agony of the Civil War had ended with the surrender of Lee at the Appomattox Court House, after a conflict to which science had added new techniques to the advantage of one side, already overwhelmingly superior in manpower and material.

Millikan came of pioneering stock. His folk had trekked into Illinois in a covered waggon train, and Millikan has recorded how (in 1873) "as a child of five, I well remember watching my grandfather—composite farmer, butcher, tanner, shoemaker—make my first pair of shoes, as those early pioneers had to do for all the members of their families." He refers to his own family as "an impecunious parson's family, well-educated, amazingly healthy. Until I was eighteen I do not remember ever seeing a doctor in the house but once."

In 1873 the family moved to McGregor, a small Iowa town on the opposite side of the Mississippi from Prairie du Chien. From his bedroom window he could hear "the reverberations from the bluffs, that there flank the great river, of the booming foghorn notes continuously sounding from the steam-boats which plied the Mississippi river."

Millikan wrote, "That was my first lesson in acoustics." (It may be recalled that Joseph Henry did some classic researches on those same foghorn notes.) He attributes his early interest in hydrostatic measurements to witnessing the river pilots taking soundings, and shouting "Mark Twain"—which one of those river pilots, Samuel Clemens, took as his *nom de guerre*.

The Millikan family moved to Maquoketa, Iowa, a town of 3000 inhabitants, near Clinton. They lived in the main street, which had its full quota of saloons—thirteen altogether. "I was exposed", wrote Millikan, "to many of the rougher influences that are often found in the small Midwest town. I have never felt that the rougher influences did me any lasting harm, and they contributed to my realistic understanding of life ... I got the other side at home." They left him with an aversion to alcohol (for Millikan cocktail parties were to fall into the category of "disintegrating and unwholesome influences . . . (and a terrible indictment of the whole of our Anglo-Saxon civilisation"); his childhood memories of those midwest saloons ensured that in later years he noted the Republican ticket, never the Democratic, which "in Iowa was for most purposes identifiable with the saloon vote".

His boyhood paralleled the life of Huckleberry Finn, He used to milk the family's two cows, and earned money "for my savings" by tending the neighbour's horse and mowing his lawn. There was plenty of fishing and baseball. Somewhat later he spent his summer holidays working ten hours a day in the local barrel factory for a dollar a day, which made him "so cocky that I proposed to my parents thenceforth to be independent of them save for board and room—a contract which I kept."

He went to the local school, which must have been good judging from this comment of Millikan's (published in 1951 in his autobiography): "I have sketched the kind of education one particular Middle-West boy got in the 'eighties. Can one get a better one now? Perhaps, but I wonder." To appreciate this remark one has to appreciate the social context of that education; a pioneering community with immense faith in its future would naturally put everything it could into education, and the good schoolmaster would be regarded as a man of great importance in such a community. Millikan considered that he had first-class tuition in algebra, Latin and history, and by methods "more effective than some more modern ones".

In 1886, at the age of 18, he went to Oberlin College, which his grandmother's brother (named P. P. Pease) had helped to found. His first two years were spent studying trigonometry, analytical geometry and Greek. In the second year he took a short course in physics, which "was a complete loss" being based on a new text-book which "we all thought both unintelligible and dull, greatly inferior to Ganot's *Physics*, which had theretofore been used."

ANY GREEK SCHOLAR CAN TEACH PHYSICS

His proficiency in Greek proved a great asset, for it led to the Greek professor asking young Millikan to teach elementary physics! The explanation of this paradoxical development is given in this note of Millikan's: "To my reply that I did not know any physics at all, his answer was: *Anyone who can do well in my Greek can teach physics.*"

Millikan, with characteristic optimism and confidence, agreed to try his hand, and got up the subject from Avery's *Elements of Physics*, an abridged version of Ganot's book which preserved one great feature of the original—the abundance of excellent problems at the end of each chapter. It was Millikan's opinion in 1951 that "I doubt if I have ever taught better in my life than in my first course in physics in 1889. I was so intensely interested in keeping my knowledge ahead of that of the class that they may have caught some of my own interest and enthusiasm." He continued to teach elementary physics until his graduation in 1891, when he was appointed physics tutor at 600 dollars a year. The money, coupled with what he earned as the college's gym instructor (!), paid all his expenses and left him with a surplus which he sent home, so helping to pay for the education of the other five Millikan boys and girls.

The speaker at the graduation ceremony at which Millikan received his A.B. degree was John Sherman, the man responsible for the epoch-making Sherman Anti-Trust Law. Two years later Millikan obtained his master's degree (A.M.) for his study of Sylvanus Thomson's new book, *Dynamo Electric Machinery*. "This may be thought a strange book for a prospective physicist to try to master, but I had no direction whatever or even association with anyone who was in the least interested in physics—another indication of the backwardness of science in the colleges of the United States at that time."

In 1893 he went to Columbia University, where he was the one and only Fellow studying physics. That year, however, was to become famous in American science for it saw one great step forward in the field of physics—1893 was the year in which the *Physical Review* was founded by Prof. E. L. Nichols of Cornell, and the *Astrophysical Journal* came into existence—the chief journals through which American physics and astrophysics were to find their stimulus and their expression. Six years later the American Physical Society was to be organised.

The graduate Fellowships at Columbia had only just been created. The key physicists at the university were R. S. Woodward (a mathematical physicist), Dr. M. I. Pupin (the brilliant Serb who had studied at Cambridge and under Helmholtz in Berlin), A. A. Michelson (world-famous for the Michelson-Morley experiment), and George E. Hale, then only twenty-four and just beginning research with his spectro-heliograph.

Pupin in particular proved an inspiring teacher. Wrote Millikan (in his autobiography): "Dr. Pupin was the first man I had ever seen who knew analytical processes well enough to come to class day after day without preparation and do his thinking in terms of equations. Watching him inspired me to see if I could learn to do it myself. Had Dr. Pupin's lectures been carefully prepared or delivered from notes, I should probably not have been inspired to try to learn his art. *Example is the supreme teacher.*"

When his Fellowship lapsed, Millikan decided to try to stay on at Columbia and to get some tutoring to keep himself. He had already started on his thesis (for which he was to receive his Ph.D. in 1895), and this work took him into the U.S. Mint where he measured the polarisation of light emitted at different angles by large pots of both molten

Millikan and Madame Curie at an international physics congress held in Rome in October 1931.

gold and molten silver. ("This was the nearest to riches that I ever came.")

Dr. Pupin was so keen for him to go to Europe to broaden his knowledge under the great masters of physics such as Helmholtz that he lent Millikan 300 dollars (on which Millikan insisted upon paying 7% interest!).

Millikan started out for Germany in May 1895, and spent a profitable period at Berlin and Göttingen.

In Berlin he studied under Planck, Warburg, Neesen, Schwartz, and Frederick Paulsen, the great educational philosopher. In the spring of 1896 he joined the new and cosmopolitan laboratory of Nernst, whom Millikan described as "a cocky little fellow with a fishlike mouth, who called me 'Herr Mōōlikan'." There Millikan worked on the anomalous dispersion of electromagnetic waves in water and alcohol. He found his stay at Göttingen especially profitable because of the stimulating seminars which were led by Nernst. He also studied thermodynamics under Voight, and geometry under Felix Klein, who did so much to boost applied mathematics (particularly aerodynamics and fluid mechanics) in Germany.

Millikan could scarcely have chosen a better time to come to Europe, for the winter of 1895 was to bring Roentgen's discovery of X-rays, a revolutionary discovery which "within two weeks" of its announcement "set the whole world agog." The actual discovery was made in November, and Roentgen read his paper in Würzburg at the end of December.

This "at once set physicists from Berlin to California trying to repeat Roentgen's experiments. I do not suppose any other scientific discovery has ever attracted so quick and so universal an interest, for it was a great new qualitative discovery that had nothing to do with precision of measurement—one, too, the significance of which appealed to everyone. . . . Scores of scientists in all countries at once dropped their pending work and began to experiment upon these strange new rays which Roentgen had named X-rays because they were such a completely unknown quantity."

Millikan is right when he said: "I have been in the habit of taking the first of January 1896 as marking the end of the old period in the development of physics and the beginning of the new. *Electronics* is the single word which best describes the new period, although the scientific world had not generally accepted the electron and the English interpretation of cathode rays until J. J. Thomson's paper appeared in the *Philosophical Magazine* in 1897. Indeed, Roentgen himself was standing out against 'the electron' as late as 1910."

In midsummer 1896 Michelson sent Millikan an offer of an assistantship in his department at the University of

Chicago. Millikan's decision was immediate: he took the first train to London, and hocked his trunk and clothes to get his passage back to America. (On the voyage he met Maurice Barrymore, father of John, Lionel and Ethel Barrymore.) He returned with a deep respect for German science but with a poor opinion of the German way of life, which he saw as heading straight for war; the puritan in him was repelled by other things in Germany, as for example Berlin's "colossal *Nachtleben*" which he insisted should be translated as "colossal vice." He was very critical of the German intellectuals in this connexion; "The German intellectuals of that day have much to answer for," he wrote in his autobiography and cites their crude Darwinistic creed glorifying war as the finest developer of man, and the way they propagated the gospel of world conquest.

THE EARLY DAYS AT CHICAGO UNIVERSITY

During his first twelve years at Chicago, he was to devote half of each day to organising courses and writing the textbooks which American students so urgently needed. The rest of his time he spent on research.

First of all he had to develop a laboratory course in Freshman physics to fit in with Associate Professor S. W. Stratton's lectures. Then in 1898 Stratton went off to the Spanish-American War, and Millikan took on the whole of the Freshman course. Initially he worked on the principle that education in the more analytical phases of physics must come almost entirely from laboratory and classroom problems; later he found he had gone too far, and reintroduced one lecture a week. ("The purpose of this lecture was not the usual one of carrying the thread of the course; rather to furnish inspiration and orientation, and to enable the student to see demonstrations too elaborate or of too qualitative a nature to fit well into the laboratory periods.")

The shortage of proper text-books had long troubled American scientists. Joseph Henry, for instance, had been a bitter critic of American reliance on foreign text-books; the copyright system was damaging American education "because unsuitable text-books pirated from abroad were cheaper than suitable books written by Americans who understood their own conditions," as J. G. Crowther summed up this issue in his essay on Henry (in *Famous American Men of Science*). Good elementary text-books were particularly hard to come by, both in Henry's time and when Millikan began teaching at Chicago.

In developing the Freshman physics course he worked up a text which was originally mimeographed for the students and then published in book form in 1903. This was entitled *Mechanics, Molecular Physics and Heat*, and had a substantial sale for the next 35 years *without revision*! Later, it was supplemented by a second volume, *Electricity, Sound and Light* (1908), the two volumes constituting a year of college physics.

In the summer term many high-school teachers of physics used to attend the university for a course on the pedagogy of their subject. For their benefit Millikan and his colleague Dr. Henry Gale, produced *A First Course in Physics*, containing an elementary classroom text and a laboratory text, which have been used by millions of students. (As recently as 1941 there was a new edition of this book, which was renamed *New Elementary Physics*.)

This period in the history of Chicago University was indeed a stirring one, as this list of staff members indicates: Michelson, Neff, E. H. Moore, T. C. Chamberlain, John M. Coulter, Charles O. Whitman, Henry H. Donaldson, William Gardner Hale, Paul Shorey, Herman von Holtz, J. Laurence Laughlin, George Hale, Frank Lillie, James Breasted, Jacques Loeb, Frank Jewett, Joe Capps, Stephen Leacock, Thorstein Veblen, Ostwald Veblen, Charles E. Merriam, Harold Ickes.

In 1899, Millikan had another trip to Europe, the prime purpose of which was to superintend an exhibit for the 1900 World's Fair in Paris. Grudgingly Michelson had agreed to send some of his instruments (his interferometer, a new harmonic analyser he had designed and the new "echelon spectroscope") and Millikan was deputed to look after them. Actually the exhibit at the Paris Fair which most impressed him, though it filled him with horror, was a German show of naval power—"huge naval guns, battleship models, and everything which goes with such armament." "Preparing for war with England was what Germany's exhibit seemed to emphasise," he wrote.

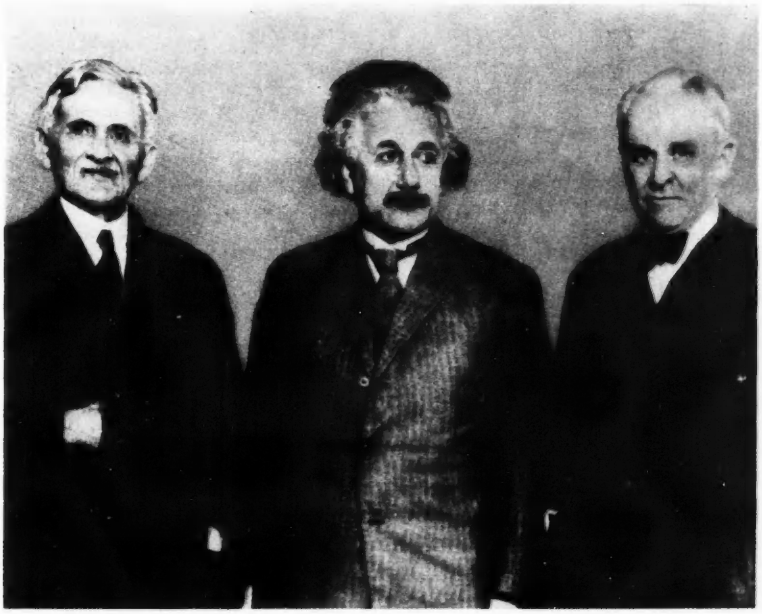
He used the trip to good purpose, learning papers and seeing demonstrations by Becquerel and Pièrre Curie. In London he visited the Royal Institution and heard Marconi lecture about long-range radio. He also attended a political rally addressed by Winston Churchill, then aged 26.

In 1902 he married Greta Blanchard, a student of Chicago University on the classics side. (Typically, he spent most of the day working, reading proofs of his *Mechanics, Molecular Physics and Heat*. "I read proofs until 6 p.m. in the downtown office of the publishers. I had a bad ten minutes when I found the exit door locked, but finally a janitor arrived and I got out in time to appear at the Blanchard home to play the assigned role.")

They spent a seven months' honeymoon in England and France, during which he found time to meet such men as Sir Arthur Schuster of Manchester, and J. J. Thomson at the Cavendish.

Weekly seminars were held in the physics laboratories at Chicago, and these Millikan organised for Michelson. One of the first research papers Millikan reviewed at one of these seminars was Thomson's classic paper of 1897, the paper which "is generally taken as marking the beginning of the modern electron theory," to quote Millikan's own phrase.

Millikan was now beginning to do a considerable amount of research. He was, for instance, working on the radioactivity of uranium ores, and on electrical discharge effects in very high vacua. Michelson, a great individualist who preferred to work as a 'lone wolf', had by now given Millikan the job of looking after the post-graduate research students, so that Millikan's plate was by now rather more than full. Nevertheless he was able to find the time for his own thriving researches. He had built some high-vacuum mercury pumps, and by 1903 he was able to obtain pure electron discharges in tubes pumped down to a pressure of a millionth of a millimetre of mercury (10^{-6} mm.). With this apparatus he was able to establish that, contrary to the



Michelson, Einstein and Millikan photographed at the California Institute of Technology, 1931.

(Reproduced from "The Autobiography of Robert A. Millikan," published in Britain by Macdonald, 1951; by courtesy of the publisher.)

prevailing view, photo-electric emission at very low pressures was independent of temperature.

By increasing the vacuum (to about 10^{-7} mm.) the tendency for a slow discharge to appear between the electrodes disappeared, and instead a brilliant white-hot spark developed between the nearest points if two electrodes three-quarters of a millimetre apart. These "hot sparks *in vacuo*" interested Michelson, who investigated them spectroscopically. Millikan himself dropped this subject for about eight years, though it was eventually to yield him big dividends. He set himself a target: "we ought to obtain a hot-spark *spectrum which will completely connect the X-ray field with the ultraviolet spectrum.* If that succeeds it will open up to exploration a big new field of physics." (This field of "hot-spark high-vacuum spectroscopy" was developed in the period 1919–30 by Sawyer, Bowen and Millikan at Chicago and "Caltech", and later by Siegbahn's team at Uppsala and others in Stockholm and Paris. It led to the important concepts of "stripped atoms" and the "spinning electron".)

CONCENTRATION ON RESEARCH

By this time Einstein had put forward his famous photo-electric stopping-potential equation, which won him his Nobel Prize in 1921. For the first experimental proof of its validity, Millikan was to be awarded his Nobel Prize in 1923.

Millikan at the age of 38 was now well established, but not satisfied with his career. He had two small sons, and was building a home that he hoped to finance out of his book royalties. His rank was that of an Assistant Professor and he had established a reputation as a successful teacher. But he realised that promotion would now depend on his research work, and he assessed his achievements in this direction in this phrase: "*I had not attained a position of much distinction as a research physicist.*"

Wisely he decided to drop text-book writing, and devote more time to research. In 1908 he "kissed text-book writing goodbye, at least for the present, and started intensively into the new problem".

"The new problem" led him to perform the famous oil-drop experiment, which is in principle so simple and beautiful that its description in the elementary textbooks cannot fail to impress itself on the minds of a schoolboy, even the schoolboy who has little interest in physics. There is no point in describing this experiment in any detail: it is far too well-known, and if you want the details they are available in Millikan's own *Electrons* (+ and −), *Protons, Photons, Neutrons, Mesotrons and Cosmic Rays* (Chicago Univ. Press, 1947).

Millikan did, incidentally, give an account of his oil-drop method to the British Association in September 1909. His talk was a stop-press item at their Winnipeg meeting, and was never listed in the programme. (J. J. Thomson was the British Association's president, and others present were Rutherford and Sir Joseph Larmor—the latter "very active in all the discussions," wrote Millikan.) The oil-drop experiment will remain a classic for all time, for it gave the most direct and unambiguous proof of the existence of the electron.

The oil-drop venture completely absorbed Millikan's energies, as this incident shows.

> To get the data needed on one particular droplet sometimes took hours. One night Mrs. Millikan and I had invited guests to dinner. When six o'clock came I was only half through with the needed data on a particular drop. So I had Mrs. Millikan apprised by phone that "I had watched an ion for

an hour and a half and had to finish the job" but asked her to please go ahead with dinner without me. The guests later complimented me on my domesticity because what they said Mrs. Millikan had told them was that Mr. Millikan had "washed and ironed for an hour and a half and had to finish the job."

HIS RELATIONS WITH MICHELSON

It should be noted that Millikan always worked in complete independence from Michelson. He "never collaborated with Prof. Michelson in any of his researches. . . . He never used me as an assistant, as he did some of the younger members of the staff. When Prof. Stratton left about 1900 to assume the directorship of the Bureau of Standards he warned me that my 'turn would come next,' meaning, of course, that friction would develop. In this prophecy he was wholly mistaken. Throughout the 25 years in which we were together, Prof. Michelson always treated me with the utmost courtesy and consideration. We were on the friendliest of terms and often played tennis together, but in our research work we went our own ways completely independently."

Michelson had had several unfortunate experiences with the research problems which he had assigned to graduate students. After a particularly bothersome bout with one in 1908, he told Millikan: "I don't want to turn over any more of my problems to graduate students. They always do one of two things. They either mess up my problem so that I cannot take it away from them and do it myself. Or else they get some real results after I have told them just how to do so and then begin to think the problem is all theirs instead of mainly mine. For the fact is that recognising a good problem is the major part of research. So this is what I propose to do: I'm going to hire an assistant who will do just as I tell him, and will not expect any credit for himself or make any demands upon me other than that I keep his weekly pay check going." It was at that juncture that Michelson turned over all his post-graduate research students to Millikan: "If you will take over all the assigning of thesis subjects I'll be your debtor forever."

Millikan was thus forced into the cooperative method of getting his research ideas carried out, and made a considerable success of it. Afterwards he was able to sum up his experience of this method in these words: "With suitable consideration on both sides it's the most effective method there is for promoting the rapid progress of the subject." He was, however, convinced that Michelson was right in shunning cooperation *in his own case*. Michelson "was by nature an individualist. It was better for him to work alone than to participate in group work. He was a very rare man in that he *analysed himself* correctly, which few of us do. And he was an extraordinarily honest man, too honest to fool himself about his own motives, as many of us do. Deceit and pretence were completely outside of his make-up. That is something that can be said about very few of us. Once when we differed and he told me he had vetoed my plan for purely personal reasons, I said to him, *You are certainly the most honest man I ever knew.*"

In 1912 Millikan visited Europe again. He went to Manchester to see Rutherford, who he thought was "unquestionably the most potent and most penetrating leader in that transformation of ideas," which explained the phenomena of radioactive decay and radioactive transformation. In his autobiography Millikan recounts how Rutherford was wont in his earlier days to enliven his accounts of research work with "pungent comments on the foibles and weaknesses of other workers, both British and foreign, a characteristic which he largely out-grew under the mellowing influence of years." Others he met included Charles Darwin, Moseley, Geiger and Marsden. In London he called on Sir William Ramsay, "then England's best-known chemist," at his laboratory in University College, Gower Street.

In Berlin the Millikans took a small flat, and enjoyed the company of Planck, Rubens and Nernst, and younger scientists like James Frank and Pringsheim. In the mid-summer of 1912 he heard all about the new von Laue-Knipping X-ray diffraction pictures: "I do not suppose there was anyone present (at the meeting of the German Physical Society at which this development was discussed) who failed to see the great significance of these experiments of Knipping and von Laue." This work was, of course, followed up by the Braggs, and of their development of the reflexion technique for obtaining X-ray diffraction patterns Millikan wrote, "Seldom in the history of physics have new results of the first order of importance been obtained in so short a time." This technique rapidly became the most popular one, and Millikan evidently considered the award of the Nobel Prize to the Braggs in 1915 a very good choice.

Back at Chicago after his European trip, Millikan was rapidly absorbed in his research activities, which were now in full spate. In 1913 he received the Comstock Prize of the National Academy of Sciences, which elected him to membership the following year.

He was now a full professor at Chicago, having been promoted in 1910. War was in the air, a war which Millikan had been expecting to come for many months; his book tells of a 1913 conversation with Lord Cherwell (then Frederick Lindemann), who explained: "Of course they (the Germans) plan to attack. Germany's chance of success in striking *now* is much better than there is any possible prospect of its being a few years from now. That is why they are going to bring on the war *just as soon as they can.*" The war started within a year of that conversation, and Frederick Lindemann and his brother Charles went to France with the B.E.F. and took part in the Battle of Mons.

During the next ten years or so Millikan was brought into close contact with industrial firms which consulted him as a technical expert on a number of patent cases, the first of which was concerned with the patentability of the 'pure electron discharge'—a key patent covering this development had been filed and its validity was being disputed by the American Telephone and Telegraph Company. (It was eventually ruled that no general patent could be granted here to either Langmuir of the General Electric Co. or Dr. H. D. Arnold of the Bell Telephone Co.) At the outset Millikan was sorry to be thrown into the field of patent litigation, but eventually he came to the conclusion that it was "on the whole a highly educative and a most useful and broadening experience—even one that contributed in no small degree to my grasp of modern physics

and my effectiveness as an organiser and promoter of research."

He came to admire the methods of the patent lawyers with whom he was associated. "The continual effort that I saw these men make to get at the real facts of a case, to treat the other side fairly, even to lean over backwards to do so, was an inspiring thing. It showed me that the objective, scientific reasonable mood of approach to problems is not at all a monopoly of science; that it is just as possible and is perhaps just as often found among lawyers as among scientists. Indeed, the two fields should have much in common. Dean Hall of the University of Chicago Law School once told me that he regarded a thorough course in physics as the best possible preparation for the Law."

MILLIKAN'S WAR SERVICE

Europe was now gripped in the throes of a war of attrition, and the chances of the U.S.A. becoming involved were daily increasing. The American scientists were already preparing for the eventuality of the U.S.A. entering the war, and in March 1916 the National Academy of Sciences pledged its resources to the President in the interest of national preparedness. A delegation from the Academy was called to the White House, and the President requested it to prepare a plan for organising the scientific resources of the U.S.A. in the interest of national security and welfare. An Organising Committee was set up for this purpose, on which Millikan served; George E. Hale was the chairman. Their plan called for the formation of a *National Research Council*, and this idea was accepted and implemented. The first meeting of the N.R.C. was held on September 20, 1916. Millikan became chairman of the N.R.C.'s Physics Committee, and also of its Anti-Submarine Committee. The detection of submarines was an obvious problem which demanded scientific study, and Millikan rapidly enlisted the aid of technical experts, both academic and industrial, to tackle it. Within a short time Millikan found himself serving in N.R.C. headquarters, and with a very grandiloquent title—"Third Vice-Chairman, Director of Research, and Executive Officer of the N.R.C." (The title was the invention of George Hale, and not just a bureaucrat's idea!) One great achievement to Millikan's credit in this connexion was his early success in getting two keenly competitive firms—the Submarine Signal Co. and the Western Electric Co.—to forget their competition and so cooperate closely in experiments in submarine detection.

After America had entered the war (April 6, 1917), no time was lost by the N.R.C. in sending a scientific mission to France.

The U.S. Army was beginning to recruit scientists. Millikan gave valuable advice here, particularly with regard to Army aviation. In general the N.R.C. organisation collaborated smoothly with the Navy, Army and government departments, but found it more difficult to work out the right relationship with such bodies as the National Advisory Committee for Aeronautics, the Bureau of Standards, and the engineering societies. Millikan writes warmly of the friendliness of Thomas Edison and Elmer Sperry, who were members of the Naval Consultative Board in Washington.

A European Scientific Mission headed by Rutherford visited the U.S.A. in May 1918, and explained what the European allies were doing about new applications of physics to sound-ranging, sound direction-finding in submarine detection, radio and infra-red signalling.

Weather forecasting was very important in military operations. This had been recognised during the American Civil War, and Joseph Henry himself took a particular interest in the development of the U.S. Weather Bureau. In World War I Dr. Blair, an old Ph.D. student of Millikan's, was given command of the field meteorological service for the U.S. Army in France. The U.S.A. was rather better set up in this field of scientific activity owing to the size and quality of its peacetime Weather Bureau.

The National Academy of Sciences had been born out of the military needs that arose in the American Civil War. The National Research Council had a similar origin in World War I. Millikan's ability and energy was a vital, factor behind the success of the N.R.C. in military matters but he was also a driving force behind the movement which converted the N.R.C. into a permanent peacetime institution and an initiator of the N.R.C. Fellowship plan which was to prove so important in the inter-war years. Millikan took reasonable pride in his wartime service, and remained for most of the rest of his life an officer in the Reserve Corps of the U.S. Army.

COSMIC RAYS AND "CALTECH"

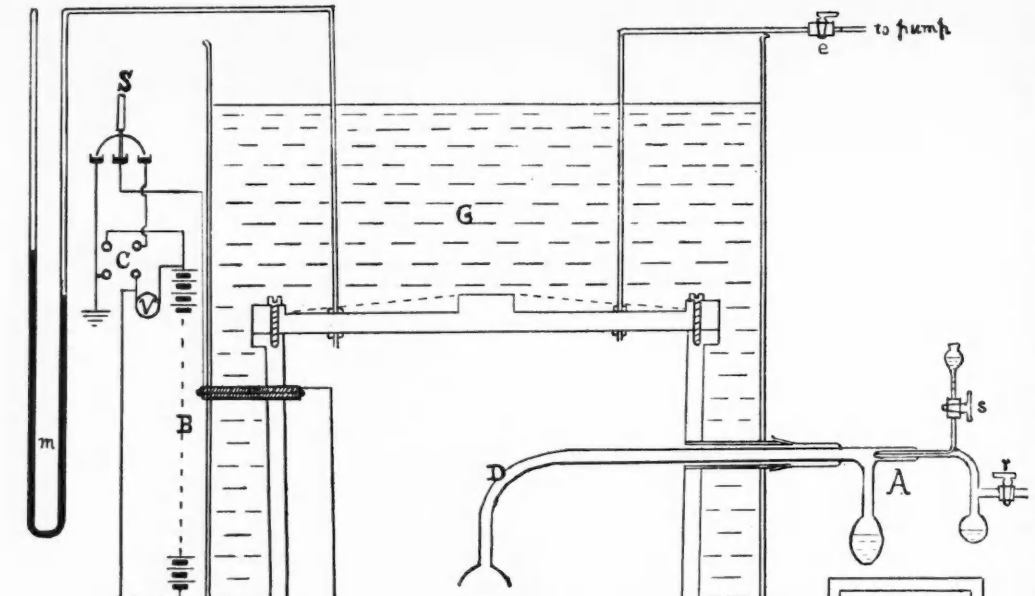
On his release from the N.R.C. at the end of 1918 Millikan was able to resume his researches. He had already become interested in cosmic rays, and coupling this interest with his wartime association with meteorological developments, he started sending electroscopes aloft in sounding balloons.

In 1921 he left Chicago to become head of the physics laboratory at "Caltech," and chairman of that institution's executive council—in practice the latter meant that he was virtually the president of Caltech, but such was Millikan's detestation of college presidencies and the money-raising activities which such presidents need to engage in that he insisted on a written contract guaranteeing that he did not have to assume its presidency!

In September 21 Millikan visited Europe and participated in the "Solvay Congress" in Brussels. During the visit he 'captured' Dr. H. A. Lorentz for the Caltech physics laboratory, and also Dr. P. S. Epstein from Leyden. In Cambridge he found Charles Darwin and arranged for him to join the laboratory in the following year. Others who came across the Atlantic to lecture to Millikan's students included Ehrenfest of Leyden, Sommerfeld of Munich, and Albert Einstein. These men, together with Richard Tolman and Harry Bateman, "gave as good theoretical leadership as could be found anywhere."

Millikan was particularly careful about the way he screened applicants for places at Caltech, and the entrance examination he helped to devise included English and history, as well as maths, physics and chemistry. This method proved effective and reduced the 'fatality' rate to the minimum.

In an early address, which, Millikan delivered at Caltech (or 'C.I.T.' as he preferred it, to match the



Millikan's apparatus for the classic experiments which enabled him to measure the charge on the individual electron. *A*, atomiser through which the oil spray is blown into the cylindrical vessel *D*. *G*, oil tank to keep the temperature constant. *M* and *N*, circular brass plates, electrical field produced by throwing on 10,000-volt battery *B*. Light from arc lamp *a* after heat rays are removed by passage through *w* and *d*, enters chamber through glass window *g* and illuminates droplet *p* between plates *M* and *N* through the pinhole in *M*. Additional ions are produced about *p* by X-rays from the bulb *X*. (*From Millikan's "The Electron", Univ. of Chicago Press*, 1917.)

abbreviation M.I.T.) he said, "The Institute is a university in the sense that it is developing a graduate school in which profound scholarship and the highest order of creative work are found." The quality of the postgraduate work done at Caltech has indeed been extraordinarily high, and this institution has done much to secure for America its fine record for progress in science and technology during the years which have elapsed since World War I. Readers who are interested will find a useful account of the major Caltech projects which have won fame for that institution in Millikan's autobiography.

The technologists trained by Caltech have done much to advance American industry, but Caltech does far more than train technologists. There is, for instance, a thriving department of Humanities, while the Kerckhoff biological laboratories gained world fame under Thomas Hunt Morgan, a Nobel Prizewinner who created the atmosphere "that has brought (up to 1951) a total of three Nobel Prizes" to the Caltech campus.

One of Caltech's flourishing technological departments is concerned with aeronautics. It was work in the wind tunnel of this Caltech unit which added an extra 35 m.p.h. to the speed of the DC-3 (the Dakota) without any addition being made to its engine power. (This achievement stirred Harry Guggenheim to tell Millikan, "I wish I had put all my money into the long-haired men!")

The cosmic-ray work which Millikan initiated has yielded wonderful results in the hands of such men as Carl Anderson (who established the existence of the meson), Seth Neddermeyer, H. Victor Neher and William H. Pickering.

* * * *

Millikan has gone, but he has left many monuments behind him, and many fine inspiring memories. As Sir George Paget Thomson has said, "The stones which Millikan has added to the building of science are massive, fundamental and well laid." This is true not only of his research, but of his teaching. For Millikan was both a great teacher and a great research scientist. There was nothing flashy or flickering about his genius, which burned and glowed steadily, like a sustained fire of great intensity. One is reminded of General Grant, of Walt Whitman's famous pen portrait of "The Silent General" in which these words occur: "The gods, the destinies, seem to have concentrated upon him . . . How those old Greeks would have seized on him."

THE NATURE OF FIJI AND TONGA

PHILIP SNOW, M.A.*

Fiji and Tonga recently, and for the first time in their history, touched the headlines. Queen Salote's visit here for the Coronation gave Tonga excursions into large print, but it required the visit of the Queen and Prince Philip in December, to give that country and Fiji their first degree of real publicity. The Press tried hard to fill in the time-lag on the *Gothic* with tales of royal ship life between Panama and the first landfall which was Fiji—a matter of two weeks. In attempting to do so they fixed in everyone's mind the watery vastness of the Pacific and Fiji's and Tonga's place in the south of it.

Fiji and Tonga, judged by world standards, both have some unusual features. Possibly the largest flying beetle in the world is to be met, quite frequently, blundering about inside one's house on a breathless, sultry night. And on one of the 320 islands in the Fiji Archipelago a heavy flurried beating of short wings and a vivid orange splash against the constant background of bush greenery gives away the presence of the orange dove, a rare bird becoming increasingly rare very fast—for reasons which will later be evident. On less than a dozen of the remotest Fijian and Tongan islands, in their dense coconut groves, the primeval, ferocious-looking but timid robber (coconut) crab survives, but only just. The sea holds huge sting-rays and surprisingly small, unintimidating octopod.

In one or two parts of Fiji are inscriptions cut into rocks, an undoubted script but so far undecipherable to all. In Tonga, the greatest character, outside the Royal Family, is a member of the nobility, at least 180 years old, in residence in the Palace grounds of Queen Salote. He is a tortoise bearing the title of Tui (High Chief) Malila, and now well known through the publicity attached to the Royal visit. On the main one (Tongatapu) of the 150 Tongan Islands, not far from the ponderous, well-preserved remains of a Trilithon and the pyramidal Tombs of Kings, is a sacred colony of flying foxes hanging head downwards all day and active at night in their tolerated depredations on bananas and passion fruit. One of the outlying Tongan Islands, known formally as Falcon Island, is in fact more often than not, not an island. An active volcano, it is only sporadically above water.

How do all these curious features fit in in relation to the general character of Fiji and Tonga?

First of all, there is a world of difference between the people of the two countries themselves, one a Crown Colony, the other an independent kingdom protected by Britain. Fiji is on the frontier of Melanesia—the most outlying spread of it eastwards. As such, it has absorbed a good deal of the most western protuberances of Polynesia, the nearest part of which to Fiji is Tonga. Fewer than 500 miles separates the centre of one archipelago from the other; the two outlying, closest edges are less than 200 miles apart. The peoples of each look quite different, the Fijians bronze, tall and muscularly built, with dominating crinkly heads of hair, the Tongan yellowish, tall and hugely built, with smooth, conventional black hair.

There are far more islands of volcanic origin in Fiji than coral atolls; almost at the thickly forested summits of the highest mountains, about 4000 ft. high, sea snails are to be found.

Round all the islands are extensive barrier coral reefs with, every now and again, to emphasise the hazards of navigation, isolated coral patches barely awash.

The earliest discoverers were cautious men, as much on account of the danger these barrier reefs and patches represented, as on account of the character of the Fijians renowned for their ferocity, waiting ashore for the great excitement and feast-producing qualities a shipwreck held. Tasman, as the first European in these parts in 1643, knew hardly anything of these perils: he sailed on the periphery of the Fiji Archipelago and clean over a reef. Cook and von Bellingshausen confined their Fijian interests to a couple of islands, Cook leaving behind some knives and medals. Captain William Bligh was the real, the unwilling discoverer of Fiji. Shortly after having been put in an open boat by the *Bounty* mutineers in the Tongan Group, he sailed through the middle of the entire Fiji Group, noting in his log the lines of the reefs, the current drifts and the contour of the numerous islands from which he kept a discreet distance. Off the very last chain of islands he was chased by spear-throwing Fijians in canoes before being able to proceed less hurriedly on the whole 3000 miles under the sun to Timor. Fiji was first called Prince William's Islands by Tasman, and then later Bligh's Islands. If honour were always done on maps to discoverers, Fiji would be renamed after Bligh: a stretch of sea there is still officially Bligh Water. Captain Wilson, in command of a ship full of missionaries, discovered another large portion of Fiji's islands some twenty-five years later.

Tonga's 200 islands are a mixture of the volcanic and the coralline. Their inhabitants were not fierce in the Fijian manner but they were the best professional fighters in the Pacific. Tasman on his first discovering them in 1643 left favourable reports, and they came to be called the Friendly Islands. Cook accorded this title; he made a point of provisioning at length there. It is believed that it was on his last visit, in 1777, that he bestowed a pair of tortoises, one of which still endures existence in the shape of Tui Malila.

The account of William Mariner, the sole survivor of a lapse of friendliness (the crew of a privateer being massacred) nearly thirty years later, is still one of the best descriptions of any land and people. Tonga enjoyed overlordship of wide areas of Polynesia (Samoa, Tahiti, Raratonga) from at least the 10th century, if legend is to be believed, and was used to having an internal settled state. This is not to say that there are not incessant

* Mr. Philip Snow, who is the brother of Dr. C. P. Snow (a former editor of DISCOVERY), was for fourteen years an administrator in the Colonial Service in the western Pacific, culminating in the post of Assistant Colonial Secretary for Fiji. He has written a book about Fiji and Tonga which will be published shortly.

intrigues to this day at a level lower than the royal one. Tonga, alone in the South Seas, keeps identity as a Pacific kingdom.

Fiji's tribes, by way of a contrast, have nominally known some degree of unity only since they agreed in 1874 to invite Great Britain to administer them. There is now beginning to arise a Government-instilled Fijian nationalism.

Two important effects on Fiji's natural history have been caused by decisions of the Colonial Government.

There used to be many land snakes of a non-poisonous variety. One tribe whose High Chief bears the title 'King of the Reefs' still uses them for their chiefly food, presenting them in baked coils to chiefs at banquets and keeping a stock of them on hand in deep pits where they are fed on special soil. They were apparently never a menace when they existed in large quantities, but the mongoose was introduced on a number of islands to kill them and also the rats. The mongoose now wriggles and rushes its way across roads and sugar fields, chased by dogs which hop upright, kangaroo-like, in the tall grass in order to keep sight of the low-slung bushy-tailed animal. The mongoose, having virtually demolished the snake and made the rat live a more troglodytic existence, has now caused many birds (the brilliant orange dove among them) to become almost extinct; it also holds the master position in relation to the keeping of poultry.

A GIANT FOREIGN TOAD

A second introduction of the Fiji Government's was the giant S. American toad from Hawaii for the purpose of eating grubs in vegetable crops. This job it has done well. It has done the job of perpetuating itself even better. To walk more than two or three paces at night on a lawn or along a track, particularly where a light shines, means a likelihood of treading on the rubbery back of a toad. Roads are dotted with their flattened corpses and the full effect of a couple of days of tropical sun on them raises the most pungent smell I remember. They eat bees, hornets, lighted cigarettes and centipedes avidly. In a matter of a decade they have caused the centipede population to drop appreciably. Soon after their introduction in the late 1930s, stomachs of dissected toads invariably contained a couple of these crooked-clawed, spiny objects. From their ponds where they lie, heads out of water, making, regular rapid throaty noises like motor-boat engines, the toads' chorus together with the sharp whine of the mosquito and the curdling howl of the wild dog in the bush, combine to make a mockery of the Still Silent Tropic Night.

FIG. 1. The Giant Toad of S. America (*Bufo marinus*).

They do, however, sometimes seek a change from this and climb the steps on to your bungalow veranda, and also up the stairs of your two-storied houses, with flabby obstinacy and a fixed determined look in their angry eyes. They are much smaller than they were on first arrival. Dogs, which at first amused themselves by trying to lift them up and turn them over, died frequently and very quickly after tasting the two glands at the back of the neck which swell up with the whole body of the toad in defence. Emetics had to be kept handy in a house, but dogs have themselves grown wary and disinterested at the same time.

Tonga has neither the toad nor the mongoose.

House residents in both countries include gecko lizards (invited or at least tolerated guests) and uninvited, unejectable squatters in the form of giant flying cockroaches with wildly waving antennae. These have a maddening liking for red and green covers of books, the nap on the binding of which they rub off with their barbed legs. A particularly fat specimen can be nearly three inches long. They tug very hard at your hair when the night is dark enough. A redeeming side of otherwise repulsively large spiders (they sometimes carry a bag which if broken causes hundreds of small spiders to scuttle off in every direction) is that they make a point of eating cockroaches.

Centipedes have venomous bites, for which washing blue is held in readiness as the antidote by the more sagacious. Bites mostly occur on toes and in bed. It was once a ritual to look under one's pillow for these eight-inch long, aggressive creatures. And one's shoes needed to be searched before putting them on. Now, their conqueror, the apparently slow-moving, but fantastically quick-tongued toad, has made this unnecessary; now you merely find a toad sitting without subtlety in your shoe. It is not easy for other than the toad to kill a centipede. Bisection, trisection, and cutting into up to half a dozen parts, only leads the parts to walk off, rather drunkenly, in various directions. Scalding water (the difficulty is to have it when you want it!) alone is visibly lethal.

A blue-and-white striped millipede, which lies in hundreds on the narrow clay paths through dense bush leading to the unsophisticated thatched villages of Fiji's interior highlands, is completely harmless and mildly decorative in otherwise undiverting bush. The bush always seems fundamentally lacking, having no monkeys and crocodiles where they would be eminently suited.

The coconut tree ceases to be ubiquitous inland from the sea or higher than a thousand feet up. Where it is to be found is also to be found the praying mantis, seldom easily visible against the background it camouflages itself into. A menace in coconut palm groves in Fiji and Tonga, not to the inhabitants but merely to the crop, is the giant rhinoceros beetle.

FIG. 2 (*left*). THE BREADFRUIT (*Artocarpus altilis*) grows 40 ft. high or more. The fruits are green or brownish-green. The famous voyage of Captain Bligh which ended disastrously in the 'Mutiny on the Bounty' was planned as an experiment in economic botany, its purpose being to take a thousand Breadfruit trees to the West Indies. A basic food plant in many parts of Polynesia. FIG. 3 (*right*). TARO (*Colocasia esculenta*). A tuberous-rooted aroid which is a commonly cultivated food plant in Polynesia. The tubers are rich in starch and are eaten boiled or roasted like potatoes. The young leaves are eaten as greens after boiling.

FIG. 4 (*left*). Bananas are widely cultivated. There is a native wild species (*Musa troglodytarum*) with erect fruit clusters. FIG. 5. THE PAWPAW OR PAPAYA (*Carica papaya*) grows 6–15 ft. high. The large yellow melon-like fruits are excellent. The green immature fruits can be cooked and eaten; the young leaves, leaf-stems and flowers can be boiled and eaten as greens. In cooking, the water has to be changed several times to remove certain bitter and harmful substances.

Creatures unfriendly and unobtrusive—too much so—in the Friendly Islands and Fiji are the silver fish which eat one's books, and the small boring beetle which flies into one's library and leaves a grub to tunnel through the paper and binding. One learns late to have bookshelves not against a wall but open at the back to allow whatever air there is in these humid parts to circulate and disturb this beetle.

FLYING FOXES

Tonga's most individual fauna is the large sacred colony of flying foxes, suspended in weeping fig trees and in the rapid dusk screeching and wheeling round not far from the capital, Nuku'alofa. These bats also exist in Fiji, some tribes eating them: they are supposed to taste like chicken, but so is almost everything one never habitually tries.

But most distinguished of all Tonga's fauna and one of the most distinguished anywhere in the world is an immigrant. The story has been passed down that the present tortoise in the palace grounds of Queen Salote, who has been a noble in the Tongan hierarchy for as long as anyone can remember in a country with no traditional written language, was originally left in Nuku'alofa by Captain Cook. Tui (High Chief) Malila may have been old in 1777; he is now somewhat decrepit. There may have been, or may be, older tortoises but one can safely say that none has been so distinguished as to attain noble rank. He is given a token share of the banquets which are the focus of Tongan life, but he prefers the normal tortoise food of leaves, insects and vegetables.

A formidable visitor to the Tongan and Fijian house is the giant flying stag beetle. It lumbers in with a great crashing noise, makes it its first action to break your petrol or kerosene lamp mantle, clutches your skin with its sharp mandibles, from which release is effected only by a burning match or a knife. Fijians eat the large yellow grub of this beetle which they find in the bark of trees. The body of the insect is six inches long; from the top of its antennae to the end of an extended leg is one and a half feet.

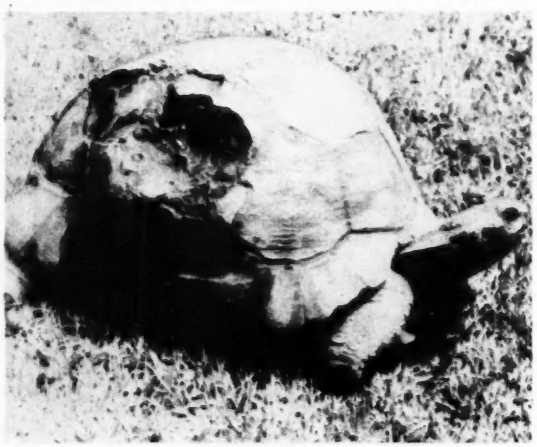


FIG. 6. Tui Malila, the veteran tortoise which Captain Cook brought to Tonga in 1777. According to Robert Gibbings, he was given apartments in the royal palace because of his great age; "When the royal kava ring is formed he takes his place, in due order of precedence and is served with his cup."

But for an almost unparalleled ferocity of appearance an otherwise retiring creature takes the prize. Two feet long and one and a half feet wide, with nippers the thickness of a wrist and having the strength to crush your fingers to the bone, the robber crab keeps largely to himself—and to palm trees. He climbs up the straight trunk of the coconut palm to the heart and breaks off stems of green coconuts which fall and occasionally crack. The crab descends backwards and breaks open the split nut: it lives on nothing else except water (but it is rarely to be seen drinking this). Fijians catch it by tying half-way up the tree-trunk a little platform of leaves, moss and earth. The crab, coming down to this, thinks that it has reached the bottom, lets go its hold, falls the rest of the way, is stunned and captured. They are sometimes kept in great tins with boulders on top and fed with coconut flesh. They are killed by inserting a palm frond in the shell and by boiling.

In the sea lie Fiji's and Tonga's big game. The most ostentatiously violent denizen is the giant sting-ray. It leaps and dives, it can present both a leer and a scowl—if you can see its expression underneath its flat frame! For, like the shark, to whose family it belongs, it is sleek and relatively featureless on its upper surface. A sting-ray drive is a special custom of certain tribes. Scores of outrigger canoes, with a spearman in the prow of each, are poled very fast to wherever one of these fish has been sighted. Harpoons are thrown into its back. It continues to move at a tremendous pace in the shallow aquamarine lagoon, clearly visible over the white coral bottom, the harpoons cutting the water like an assembly of periscopes. Eventually, after a succession of towering, angry leaps, it tires and is then punctured by masses of spears. Then its poisonous, jagged barb at the base of the tail is cut off—a manœuvre always calling for adroitness. Although shark is never eaten, the ray is. Rays often bury themselves under the sand, and can throw anyone treading on them high up into the air and then down on to their barbs to die rapidly in agonised paroxysms.

Sharks have nothing like the same reputation, at least in the South Seas. Lazy fat ones are sometimes found 70 miles up the considerable rivers of Fiji. They loiter below the steep banks on which inland villages are situated waiting for the children to come down to bathe twice a day in accordance with Fijian habit. In ten years or so of sailing (not for pleasure, but as part of my job as Magistrate and District Commissioner) between the many parts of the Fijian Archipelago, I saw only one shark. This was a small one, six inches long, stranded in a coral grotto left uncovered by the receding tide. Sharks are said to be most attracted to white flesh (the most easily visible) and the quietest persons. Fijians bathe with much shouting and rollicking, largely an anti-shark precaution.

BARRACUDA AND GIANT CLAM

Barracuda are held in much greater awe. They are more streamlined, more deliberately aggressive and not put off by noise. Jagged-edged heads of quite large fish found washed up on the dazzling white coral beaches are believed by natives to have been the results of raids by barracuda.

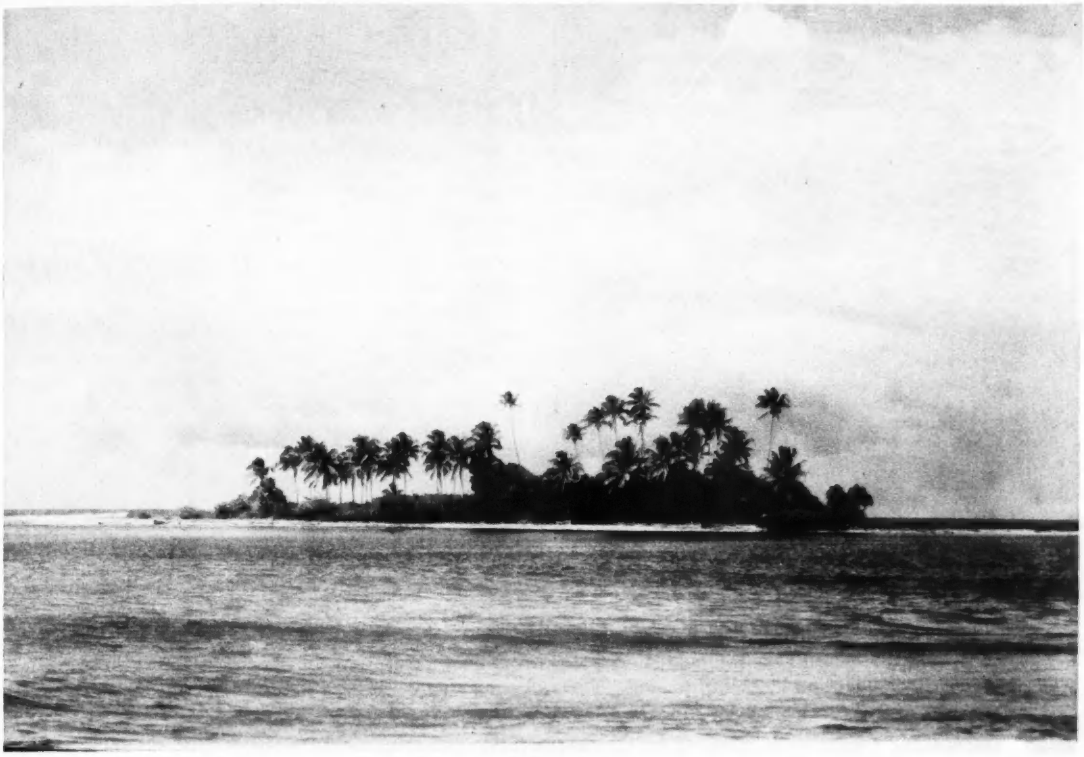


FIG. 7. An islet of an atoll typical of the western Pacific.

As a contrast to the extreme speed of these predatory fish and to the twinkling, irritatingly short dashes into the light from dark coral hideouts of the little cobalt and scarlet fish, the lagoon beds are covered with immobile or almost immobile objects. These are star-fish and *bêche-de-mer* (sea-cucumbers), looking remarkably unliving and of little interest except to the Chinese, and then as food. Nearby, where the aerial roots of the mangrove trees project out of the black mud at the junction of creeks with the sea, mud-fish hop, to nowhere in particular but moving very fast on top of the water and along tree branches.

A good detective story by an American, the late John Vandercook, *Murder in Fiji*, has as its climax the villain thrusting the sleuth, who had half-suspectingly gone reef-fishing with him, into the gaping jaws of the giant clam-shell, leaving the tide to drown the victim (which, one need hardly say, does not eventuate). A snag in the reality of this is that a clam closes slowly, imperceptibly almost, on its prey, and one would need to have a fairly insensitive foot not to know that it was inside a clam. Once a clam has closed, a crowbar is required to make it open again.

Its flesh is as tough to eat as a turtle's. This is unfortunate because turtle is the chiefly South Seas food, the head being reserved for chiefs and European administrators. When puffing on the surface of the water is noticed men throw spears and then dive underneath to turn the turtle with a deft movement over on its back, all the time keeping well clear of the very powerful flippers. The turtles are then kept in a round pen, made of thickets and stakes on the edges of the lagoon, which is reserved for them. When a banquet is near, they are presented lying on their backs amid much sighing and puffing. They lie like this, I regret to say, for some days before dismemberment that is supposed by custom to be gradual in order to maintain their edibility. The mottled shell of the hawksbill is made much use of by the souvenir shops in the two capitals, Suva and Nuku'alofa.

SEA SNAKES AND HEDGEHOGS

Turtles are quite prolific, as also are the handsome black-and-white, regular-banded sea-snakes with golden heads which, unlike the land-snakes, are regarded as poisonous. Fijians do not drape them round their necks as they do with their land counterparts.

It is highly inconvenient when a group of sea-hedgehogs, their six-inch long spines radiating from a single red eye in their middle, assemble in the only narrow opening in the shore reef where you have to wade out to your dinghy or launch. Quite apart from the razor-like edge of the coral gardens themselves, these echinods alone require you to wear shoes when exploring the reef. There is nothing that leads faster to a virulent poisoning than a coral cut. Most

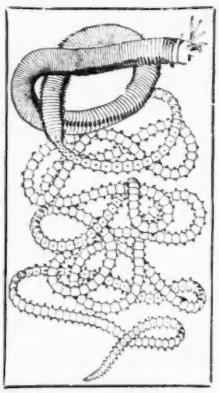


FIG. 8. The Mbalolo worm (its scientific name is *Palolo*, or *Leodice*). It lives in fissures in coral rock. It swarms twice a year; the small October swarm gives the month its name—Mbalolo Laili; November is Mbalolo Levu ("the large swarm"). The worm is 16 in. long.

amputations in the South Seas are, if they are not the result of meetings with barracuda or shark, due to ulcers caused by coral gashes.

Fishing is done communally. It is the province largely of the native women. They half float, half swim, in the lagoons for a great part of the day. They sometimes have chunks of bamboo as supports under their arms and they wear 'suvamarina', cheap submarine goggles, for the frequent diving to net fish or to turn octopod inside out. Almost the only time men use the net (they do not often go spearing, and angling is unknown) is on festival occasions when they intersperse with women, holding a net half a mile long made of palm fronds tied together. They spread in a half-circle well out in the lagoon, gradually drawing in a diminishing area of net to the shore. When the shore is nearly reached the enclosed water is effervescing with fish, principally mullet, which are neatly caught by women who bite off their heads and throw them as fast as they can on to the beach.

TUNA

The most recent large-scale commercial enterprise in fishing was organised by Harold Gatty. It will be remembered that he was navigator with Wiley Post as pilot on the earliest flight round the world. He now lives in Fiji, halfway between the Fiji capital and the Tongan capital, and is rapidly becoming an expert on the Pacific. South Sea Marine Products under him introduced, after a couple of years' comprehensive study of all waters of the Group, a considerable fleet of ships and fishermen. It had to admit failure recently after two years' actual operations. It had concentrated on tuna which in tinned form in America fetches a high price. Tuna there were and are in great quantities in Fiji. They compose the big shoals one is always passing through in Fiji—spectacular schools hovered over by as many sea-birds trying to pick the scales off their backs as they bound about. But they refuse all baits offered. Nets were tried: these were also successfully eluded. Hauls were negligible. It is thought that with so much natural food for all fish on the reefs they find no need to accept it on a line. A year ago, however, there was a huge acceptor of a bait in Fiji waters—a silver marlin of nearly 400 lb. caught by the visiting American Governor of Eastern Samoa.

MBALOLO

A phenomenon of these parts is the *mbalolo*, a marine worm which rises in millions of spaghetti-like fragments on a set day of the year in certain parts of the Groups. It advertises its intended feat some weeks in advance by a particularly powerful ozonic smell and it is collected as fast as it rises by large parties of people in boats at dawn, some of whom put it straight in their mouths while others prefer to cook it for breakfast.

Whales are almost never seen. A tremendous event it is when one is stranded on a beach. Such whales as there are are inevitably cachalot or sperm whales, with forty to fifty teeth, each six inches long and two inches wide, in a mouth. Up to the time of the first Europeans at the beginning of the 19th century, who were either whalers needing fruit, water and an escape from their occupation, or traders in sandalwood and *bêche-de-mer*, Fijians had employed wooden and stone phallic symbols for their ceremonies. The whalers, in exchange for provisions, offered the ivory teeth of similar shape which became much coveted by the Fijians. The Tongans had no interest in them. Today, whales' teeth are the most important ceremonial gift of a Fijian. A hundred of them, a ceremonial number, were presented to the Queen in December. A shortage in Fiji has been caused by their having been smuggled out, despite the prohibition of their export, during the war by American and New Zealand troops. In the old days whales' teeth were passed round between chiefs: they were an ambassadorial currency to achieve an alliance, to bribe an assassin, to bring about a murder or a marriage, to mark a birth or to express sympathy in death. The recipient is required to do what the donor requests. Despite the incentive, there has never been any whaling done by Fijians. Whales prefer distant, colder waters.

To those who expect the tropics to have brilliant-looking and powerful-smelling flowers the flora of Fiji and Tonga is a disappointment. In the bush there is a conspicuous absence of colours and smells; all is green in its manifold shades. A momentary splash of colour is provided, not by the flora but by the fauna—chattering parakeets and swooping kingfishers.

FIG. 9. Coral fishes of the western Pacific. (Reproduced from Robert Gibbings's *Over the Reef*, Dent, 1948, by permission of the publishers.)

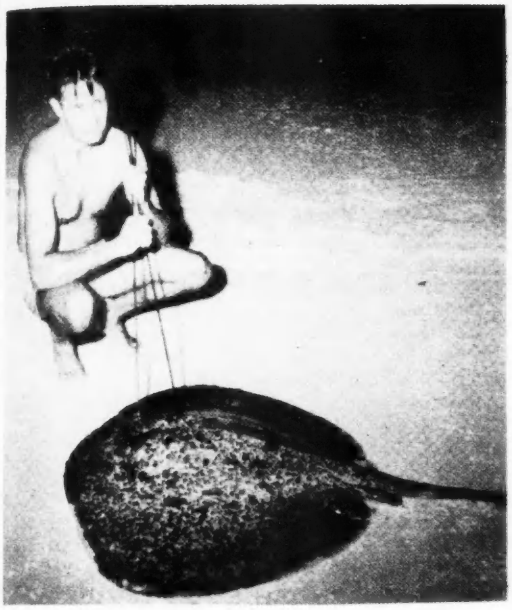


FIG. 10. Giant sting ray

FIG. 12. A 40-inch-long clam, the giant *Tridachna*. (From Smithsonian Institution Annual Report, 1947)

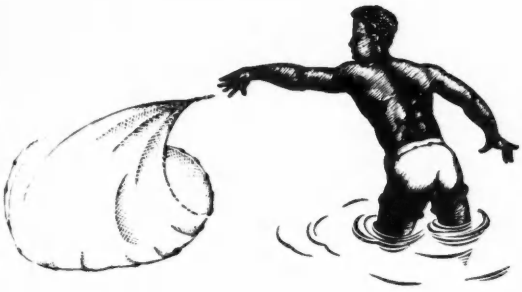


FIG. 11. The throw-net is circular, and weighted with small leads around its whole perimeter. The net spreads to its widest upon striking the water, the sinkers carry its edge quickly downwards, the fisherman draws it in by a central cord and as the weighted edge closes in the fish are enmeshed. (Reproduced from Robert Gibbings's *Over the Reef*, Dent, 1948, by permission of the publishers.)

On one Fijian island, Taveuni, is a rare flower, *tangimauthia* ('weeping in the wilderness'), a kind of edelweiss found only in the lakeside crater of an extinct volcano, 4000 ft. up.

Where the Fijians came from initially is a tantalising mystery. One might hope that the existence in two separate parts of the islands, 200 miles apart, of rocks on which characters, somewhat resembling each other, have been deeply inscribed, would contribute towards a solution. They are understood by no Fijians. The British Museum has seen similarities between the script and Kharosthi, the language of the Punjab from the 5th century B.C. to the 4th century A.D. After some research into them and excavation on the site (the major of the two collections is in a remote spot on the side of a hilly bush track) I am in no way further ahead with a theory; but it is possible that they hold an important clue which may be deciphered one day.

Tonga, unlike Fiji, has no minerals or rivers; it lacks islands of the size of the two large ones in Fiji (one 90 miles by 60, the other 100 miles by 20). There are more coral atolls in Tonga, and burnt coral from the reef is used widely for building churches and houses. Coral limestone is the material in the huge Trilithon, an archway known as the Ha'amonga-'a-Maui, the uprights of which are nearly twenty feet high. Whether it was hoisted or raised by rollers on a ramp is not known. Nor when it was erected. Near by are the ancestral tombs of the kings of Tonga, huge coral platforms in a pyramid shape. Where the Tongans came from is as large a mystery as in the case of the Fijians; in both instances a wide field of conjecture is opened up.

The Edible Dormouse in attitudes of climbing, feeding and sleeping. Sketches from life by the author.

THE EDIBLE DORMOUSE IN BRITAIN

ALFRED LEUTSCHER, *B.Sc.*

The Edible Dormouse (*Glis glis*) was introduced into Britain about fifty years ago, and is still very much a novelty. The date is given as February 4, 1902, when some specimens (either from Germany or Switzerland) were turned loose at Tring Park in Hertfordshire by Lord Rothschild. Soon after, it is said to have increased rapidly, doing damage to crops and the thatch of outhouses, and an immediate campaign against it resulted in near extermination. Little was heard of it until the twenties, although occasional specimens were sent to the Zoological Gardens in London. By about 1926 it was again reported in numbers in Tring Park, and from then onwards began to make itself known in houses and buildings in Tring and neighbouring villages. By 1931 it had reached Whipsnade in Bedfordshire.

Because of a possible risk of its becoming a pest, a factor always to be considered where introduced animals are concerned, especially rodents, a survey was commenced in 1951 by the Ministry of Agriculture. Squirrel clubs, agricultural committees, naturalists and interested country people were informed and some publicity was given in the daily press. Wherever possible, records of past deaths and captures were noted, and the data compiled on which to assess the increase and spread of this rodent. Figures which have since been published, and are given in decades, are as follows: 1902–10 (?), 1911–20 (?), 1921–30 (43), 1931–40 (152), 1941–50 (321). This suggests a gradual increase in population. The present *Glis* country comes within a rough triangle of some one hundred square miles, bounded at the corners by the towns of Beaconsfield, Aylesbury and Luton, with Tring as the centre of irruption. During its spread it seems to have lived, here and there, in isolated colonies mostly in buildings, from which it may have been exterminated, and then reappeared after many years.

My first introduction to this attractive little animal was in early April 1953. Some friends living at Albury, a village near Tring, phoned to say that one had been discovered in a rabbit burrow. It was in a biscuit tin when I received it next day. Having had some previous experience with rodent bites (which can be dangerous because of the deep punctures made by the incisors) I put on some gardening gloves before removing the lid. I uncovered a bristling ball of biting fury, which growled at me continuously until it was hastily bundled into its new home. The sound it made is difficult to describe, but can be likened to the noise made by a car engine which is being started on a run-down battery.

The new home which we gave it was a large aquarium, sprinkled with earth and containing a drinking bowl and some stout branches. A large flower-pot placed on its side and filled with hay served as a sleeping quarters. Entry was made through the enlarged drainage hole in the bottom. A roof of strong wire netting made this cage into a stout prison for the type of animal which could easily gnaw its way out of the more usual wooden hutch.

An apple was placed in the cage. One would have thought that the experience of a long and bumpy journey, confined in a tin and subjected to strange smells and noises of trains and car, would have cowed our newly acquired pet. On the contrary, it showed every sign of enjoying its meal. Afterwards it perched on a branch and washed its face, licked the soft grey body fur, and even combed its bushy tail and cleaned its feet. It then retired into the flower-pot, so we left it with a supply of hazel nuts till the next day.

During the night the rest of the apple was eaten down to the chewed remains of the core and skin, and most of the nuts were broken up. Throughout the summer it continued to feed on apples, and soft fruits like plums, cherries and pears. Greenstuff was largely ignored. In autumn when hard fruits were obtainable, hazel nuts, walnuts, chestnuts and acorns were given. Various seeds, wild fruits and tender twigs were included in the diet, but on the whole

apples and nuts were mostly preferred, with the apples as a priority choice. Sometimes two a day were eaten. Our pet seldom drinks water, but may occasionally lap up milk.

The process of taming it took about three weeks, and was a matter of patience and strict routine. Every evening, wearing gloves, I carefully picked it out of the nest, and my wife then gently stroked it along the back and behind the ears. We spoke to it in soft, baby talk, and offered titbits. The idea behind all this was to associate human voices and touch with pleasant things like feeding and fondling. At first it would bite furiously, and throw itself on to its back inside the cage, in a curious defensive attitude, warding off my fingers with its paws in a useless fashion. In the face of a natural enemy, such as a pine marten, polecat or wild cat, this would seem to be a dangerous practice, since the underparts become exposed.

In about a fortnight this behaviour suddenly stopped, and our dormouse no longer bit the gloves. One cannot say what mental process, if any, was involved, but with a change in animal behaviour of this kind, one could reason that since no harm befell this animal, there would be no point in continuing to bite and struggle. From that day on it has never attempted to bite, and can be picked up with the bare hands. It must, however, be done regularly. Although timid and easily upset by sudden movement and noise, it will now sit upon my shoulder and climb up the arm or leg.

Its remarkable climbing powers were amply demonstrated during a brief spell of freedom. One evening the lid was left unfastened, and that night we were awakened by a loud scampering and thumping noise coming from its room. Our pet was at large, and although both window and door were left open, it made no attempt to leave the house, but sought refuge in the chimney. No amount of persuasion would bring it down in our presence, in spite of calls and offered titbits. This waiting for it to appear turned into a game of hide-and-seek—as soon as we left the room it would come down and continue to romp and play, punctuating our sleep with its boisterous games.

When this dormouse takes up residence in people's houses in the Tring area, especially in attics where apples are stored, the residents report that the antics may be likened to a football match. Apples are rolled about, and the patter and thumps of little bodies and scampering feet sometimes precludes any slumber.

After about a week we finally caught our dormouse in a net. By then the room was everywhere covered with its sooty footprints, which marked the furniture, curtains and even the picture-rail. Had there been any projections on the ceiling it would probably have gone up there as well.

The natural environment of the Edible Dormouse is the deciduous woodlands of Central and Southern Europe. It extends from the Atlantic coast, in France and Spain, eastwards to the Caucasus and parts of South-west Asia, and from Germany and Russia in the north to Italy and some of the Mediterranean islands in the south. Nowhere does it appear to be a serious pest, with the possible exception of the Caucasus area, where it will descend on the fruit orchards if the acorn crop happens to fail. In Britain it is seen or found mainly in lofts and outhouses where fruit is stored, and will spend the winter there. It is usually tolerated until the colony becomes too large, and it causes a nuisance by its noise and damage to apples. Occasionally it turns up out of doors, usually in summer, and may be discovered in a hollow tree or rabbit burrow.

It is still regarded as a novelty, and the fact that few people outside its area in Britain are aware of its presence, even after fifty years, may be taken as a good omen. It means that this little alien is not making itself too obvious, and cannot yet be looked upon as a pest. After the costly lesson of the rat, rabbit and grey squirrel, all of which were introduced, it is a wise precaution on the part of the authorities to keep a close watch on this newcomer. So far no damage to trees or fruit crops has been reported. Because of its preference for dwellings and outhouses in Britain, it is taking on the role of a commensal, sharing man's home and at most only have a nuisance value. Its confident nature makes it easy to trap, and it will readily take poison bait. As many as seventy-five individuals have been caught in one country house near Tring, in the space of two months. It frequently drowns in water cisterns.

Such a trusting nature, quite alien to that of the wary grey squirrel, makes it easy to control, and a Ministry of Agriculture report from Mr. Thompson states that "while it remains localized and few in numbers there is no cause for alarm, especially as it is so easily controlled".

Glis glis is a rodent of the Dormouse family, which feeds mainly on nuts and soft fruit. Larger than the Common Dormouse (*Muscardinus avellanarius*), it has a six-inch body, weighing about six ounces, with a soft, short coat, usually a silver-grey with light flanks and underparts. The squirrel-like face has a whiskered muzzle and dark eyes ringed with black. The large, rounded ears are like those of a dormouse. The naked feet with rudimentary thumbs have rough pads which give a clinging grip so that it can climb expertly, even up a rough-cast wall. The tail is bushy, squirrel-like, and about body length. It is known by various names. Those of Edible or Fat Dormouse remind us of an old Roman custom. In Italy where it is very common, colonies were kept in specially planted enclosures of oak and beech. When required for the table, individuals were confined to earthenware jars, called *gliraria* (*glis* means dormouse—hence the scientific name), and fattened on walnuts and chestnuts. When cooked they were served with a sweet sauce, such as honey. Local names for it in the Tring district are Squirrel-tailed Dormouse, Spanish rat and Little Chinchilla. The Grey Squirrel is called the Chinchilla. In a large house I know near Tring, where *Glis* was once in residence, there is a store cupboard in one room, still referred to as the Chinchilla cupboard. In Germany it is called the Siebenschläfer (Seven-sleeper), because of a deep winter sleep said to last for seven months, from September to April. Up to the time of writing, December, our pet has shown no signs of hibernation, due possibly to the very mild weather and warm indoor conditions.

REFERENCE

"The Edible Dormouse (*Glis glis L.*) in England, 1902–1951, by Harry V. Thompson (Ministry of Agriculture and Fisheries, Infestation Division, Surbiton). Proceedings of the Zoological Society, 122, 1953, pp. 1017–24, with two illustrations and map.

INGENUITY VERSUS DISABILITY

TERRY GOMPERTZ

The patients who come to the Occupational Therapy Department of King's College Hospital represent almost every kind and degree of physical disability. Their problems are familiar to anyone who has to do with the elderly, the permanently disabled and those whose lives have been temporarily dislocated by accident or sickness. What deserve to be equally widely known are this department's ingenious solutions to these problems, derived from an imaginative application of modern theories of rehabilitation.

Many people might be surprised to find so great an emphasis on mechanical aids to living and so general a use of tools and machinery in an occupational therapy department. Even some doctors probably still think of the occupational therapist primarily as a craft instructor; someone able to keep hospital patients happy and amused by teaching them to weave scarves and rugs or to make baskets and lampshades. But the occupational therapist is a fully trained medical auxiliary and his or her knowledge of crafts is merely a means to several ends, of which diverting a patient is only one.

For instance, by means of adaptations to differing types of looms, weaving becomes a most valuable remedial exercise for a wide variety of cases involving physical disability. The great value of these crafts, and of all work therapy, is that while the patient's attention is concentrated on making something, the movements necessary to his own recovery are performed automatically.

AIDS FOR DISABLED HOUSEWIVES

However, work treatment alone does not supply the answers to many of the most pressing problems of either the temporarily or the permanently incapacitated person. For example, the chief worry of the housewife left with a useless limb, or limbs, after an attack of poliomyelitis is as to how she can cook, do the washing, ironing and her housework properly. The answer to that question can only be found, first by a careful study of the movements and effort involved in such occupations, and then by working out the best possible use of a patient's residual capacities—including the devising of mechanical aids to supplement those capacities.

A similar approach is the only answer to the often overwhelming difficulties faced by those with chronic and sometimes progressive disabilities. For those who suffer from cerebral palsy, rheumatoid arthritis, osteo-arthritis, and many of the nervous diseases, the most urgent need is for the working out of aids and methods by which they can be made less dependent on others in activities such as dressing and feeding and personal hygiene.

These people's lives can be further transformed if some useful and enjoyable occupation can be found that is within their limited capabilities, and which can take the place of the more active hobbies their illness has forced them to give up.

The two major centres of activity in the department are a combined kitchen and living-room and a heavy workshop. The kitchen has been set up at one end of a large room in a space of about fourteen feet square. It was originally planned to be workable for a woman with paraplegia, confined to a wheel-chair and living alone; in other words, for someone very severely disabled. But many differing forms and degrees of disability have been catered for with the intention that, wherever possible, the same sort of adaptations and gadgets, or modifications of them, can be made available in the patient's own home.

As can be seen from the illustration on page 77 the layout of the kitchen is not very different from that which an able-bodied woman might well plan for herself if she were able to do so. As far as possible everything is at the same level and within easy reach. The object, of course, is to reduce stooping and stretching to a minimum.

The cooker and gas burners stand next to each other. At the sink there is a mixing tap with lever handles and a swinging delivery pipe so that kettles and saucepans can be stood on the draining board and filled without the effort of holding them. On the right side of the sink there is a pull-out flap with holes in it to keep mixing bowls, jars and tins steady. Fitted to the wooden surface from which this flap pulls out is a universal clamp designed and made by a technician in the hospital physics workshop. On to this clamp a one-handed person can fit a number of cooking tools, such as a potato peeler, mincer, grater or an egg whisk.

In the right-hand corner is a cupboard with revolving shelves, enabling its contents to be easily reached. This was made in the department with the help of the hospital engineers—as was the very ingenious walking trolley shown in the right forefront of the illustration. The trolley, made to the same height as the kitchen unit, provides a patient who has difficulty in walking with a prop at the same time as she is transporting dishes. It has a flap which acts as a ramp along which a dish can be slid from the oven to the trolley or from the trolley to the dining-table.

For all those with weak or useless shoulder or arm muscles, there is an overhead track right round the kitchen so that they can move from job to job with their arm supported in a sling—thus giving them a powerful leverage to compensate for the useless levers of their own body.

In the left forefront of the illustration is shown a high stool for arthritic patients who can do a lot of work if the greater part of their weight is taken off their stiff and painful joints and supported mechanically. These stools are made to measure, in the heavy workshop, either by other patients as part of their work treatment, or even by the arthritic patients themselves.

Each day a number of patients prepare and cook a midday meal for themselves and some of the others. This ensures, not only that the patients acquire confidence in their ability to cope, given such mechanical aids, but also that their individual problems are constantly challenging the imagination and enriching the know-how of the occupational therapists treating them.

FIG. 1. An arthritic patient is able to beat an egg—aided by the sling and the universal clamp which holds the egg-beater. (Before her treatment she had been completely dependent on others for eighteen years. With such aids as these she can now prepare, and wash up after, a meal.)

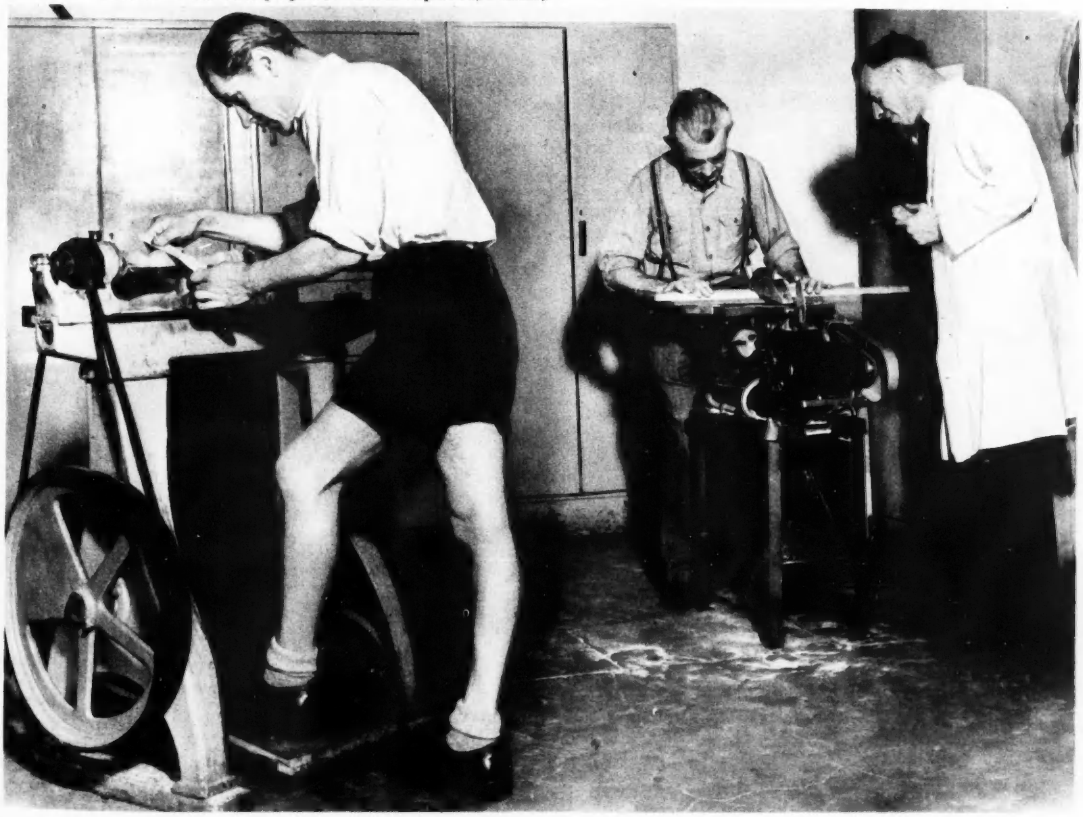


FIG. 2. Two patients in the heavy workshop, supervised by a technician. The man on the left is using the treadle lathe to aid his recovery from a fracture into the knee joint. The other man is being reaccustomed to the use of a power saw.

(Air Ministry photograph, Crown Copyright Reserved.)

As has been said, the technical adaptations in this kitchen, and others to ease the difficulties of housework, moving from room to room and personal hygiene, can be, and are, applied to a patient's own home. The two local councils in the King's College Hospital area have agreed to do the work necessary for such major features as the installation of a sling track, or ramps to facilitate movement in wheel-chairs. But as far as the minor improvements are concerned, once the family handyman has had a look at the kitchen and the gadgets, there are any number of things he can make or adapt. The husbands and relatives of these women patients are encouraged to come and see what can be done and to contribute new ideas.

THE PROBLEMS OF INDUSTRIAL WORKERS

The heavy workshop next door to the kitchen provides a striking variety of treatments for widely differing cases. It is well equipped with the normal range of woodwork and metal-work tools and machinery. (Incidentally, much of the equipment, such as tool cupboards, work benches and so on, was made by patients in the course of their treatment.) Many of the patients here are recovering from injuries received in accidents of one kind or another. A high proportion will be returning to their own jobs and the main object of their work treatment is to bring about as speedy and complete a recovery as possible. Particularly in the case of industrial workers who have had a long illness, however, there is a further problem. They often feel the need for reassurance that by the time they are medically fit to return to their job they are also completely fit to cope with a full day's work in normal workshop conditions. So a valuable last stage in their treatment is to spend some days doing work as similar as possible to their own.

There are always a number of cases who, on account of their illness or accident, may be unable to return to their former jobs—though they are perfectly capable of doing a full day's work if their particular disability is no bar to efficient performance. Since the Disabled Persons Act of 1944 these people are eligible for retraining and resettlement in some suitable employment, and the work they do in the occupational therapy workshop is a useful guide in assessing their capabilities and aptitudes for a new type of job.

Now whereas in planning and devising the kitchen and household apparatus the therapists' and technicians' ingenuity is largely devoted to calling on mechanical aids to work for inadequate or absent body levers and muscle power, in the heavy workshop they often have to use much imagination to produce almost the opposite result. So that one finds a machine, originally designed to perform an operation with the minimum of effort and movement, adapted to produce the same result with a greater degree of effort and with a particular movement required to suit some special condition.

A good example of this is the combined electric mortice chisel and drill. By means of a simple shield on the hand lever, the kind of grip with which it is operated can be altered. In the case of recovery from an ulnar nerve injury, for instance, it may be necessary to encourage the flexion of the fourth and fifth fingers and discourage the use of the thumb and first. So the shield will be so adjusted as to leave room for the third, fourth and fifth. If the gripping power of both hands needs improvement a second lever can be used. Or it may be desired to exercise the shoulder joints or upper arm muscles, such as the biceps; the lever or levers can be adjusted to do this. By the attachment of a spring grip the patient can be made to use the machine against a specified resistance.

In order to provide comparable treatment for injuries and disorders affecting the lower part of the body the obvious mechanism is a bicycle. Until recently the usual, but very inadequate, answer to the occupational therapist's need for a leg-power driven machine has been a bicycle fretsaw. So the present pride of the department is a stationary bicycle, the first machine of its kind to be made by a firm of engineers who specialise in medical equipment. This bicycle drives a flexible cable producing a rotary movement suitable for a variety of operations. The machine has been designed to allow for the varying limb proportions and weights of individual patients and is fitted with a highly adjustable crank providing for a great range of knee movement—from minimal to almost full. An adjustable brake allows for differing degrees of resistance. At the moment there are ten gears to cope with widely differing timing needs, but one improvement will be a still higher gear to help the patient who can only pedal very slowly.

At present the work done on this bicycle is confined to drilling operations—required in such jobs as preparing the bases of baskets, bristle holes in brush handles and so on. But it is hoped to extend the use of the machine to other operations performed by a rotary movement, such as polishing, grinding or light lathe work. It is obvious how great a variety of conditions can be treated by means of a working period on so flexible a piece of machinery as this.

The greater the number of obviously useful jobs which involve the use of such machines, and of the normal wood and metal-work tools, the better. A very sensible arrangement has been made between the department and the hospital authorities which provides a steady demand for certain types of work. For instance, the hospital needs a constant supply of the foot-rests which form a walking fulcrum incorporated into foot and leg plasters. The department contracts in the normal way to supply these 'rockers', as they are called. The eight separate operations required for the making of these 'rockers' furnish an excellent example of the way in which the occupational therapists have applied normal working processes to the needs of a mixed group of patients.

First, the plywood sole must be marked out around a template. This job can be given to anyone needing to establish some degree of accuracy and control in their movements, or to assess their progress towards it.

The cutting out of the soles is done either on a bicycle or treadle saw and provides the treatment necessary for those recovering from hip, knee or foot injuries and operations.

The filing or sandpapering of the edges is a useful exercise for anyone requiring a continuous horizontal movement and can also be given to bed patients. It is good, too, for anyone with stiff fingers.

FIG. 3 (*left*). Lever handles and a swinging delivery pipe make it possible for a paralysed patient to fill a saucepan. She would not have the strength to hold the saucepan under an ordinary tap. FIG. 4 (*right*). A young housewife severely crippled as a result of poliomyelitis—the only power she has left in her upper limbs is that of her right forearm and hand. But with the aid of the sling and other devices for the one-armed she can prepare, cook and wash up after, a meal.

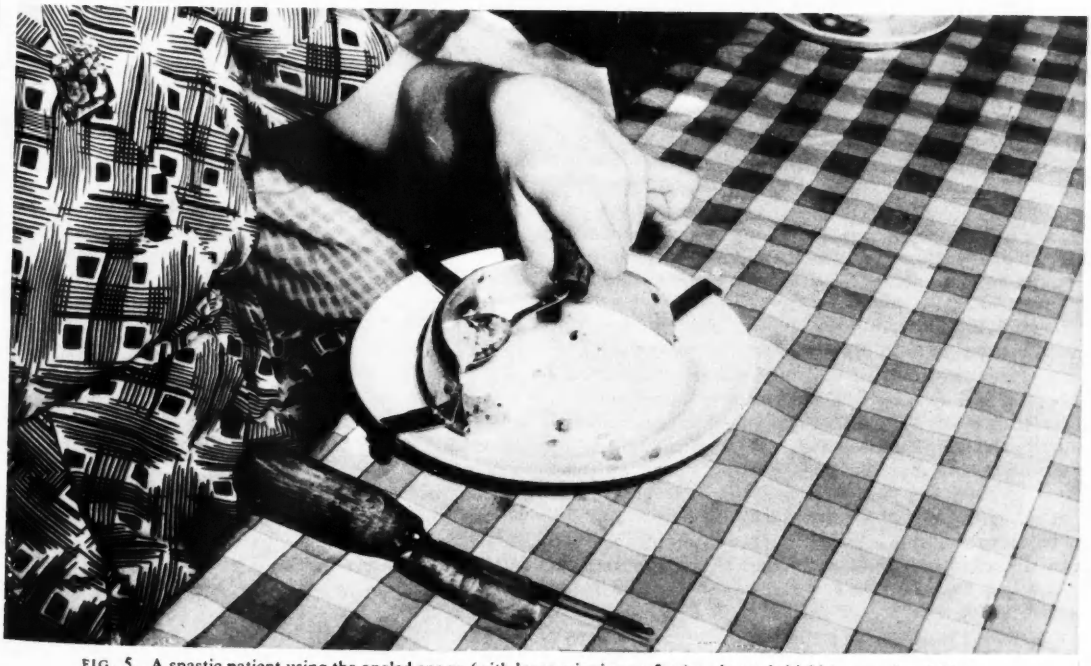


FIG. 5. A spastic patient using the angled spoon (with large gripping surface) and metal shield to ease the picking up of food and prevent it being spilled on table or clothes.

FIG. 6. A patient using the power drill to exercise the biceps of his right arm.

The fourth operation is the drilling and countersinking of two screwholes and this can be given to someone needing to use the combined drill and mortiser described on page 74.

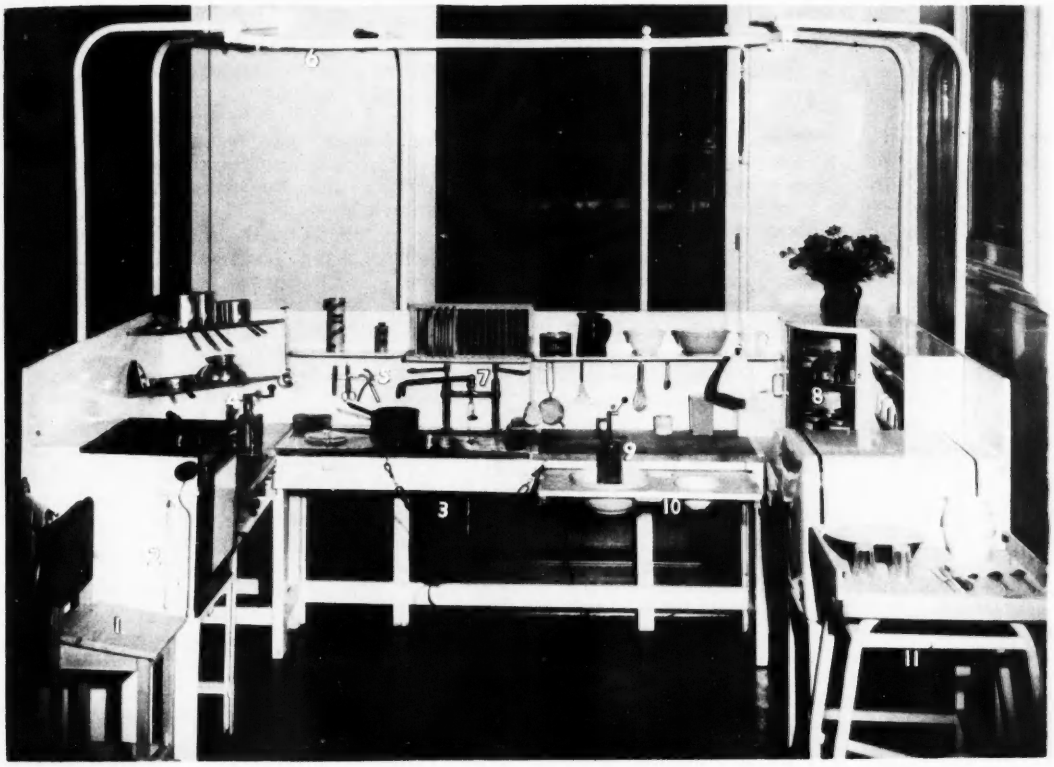
On to the plywood base is fixed the 'rocker'. This must first be sawn from a length of half-round moulding. The sawing may be done by any of the many patients for whom a spell of work with a handsaw is wanted, or by a man, such as a wood machinist, who will be returning to a job involving the use of a circular saw and is glad of the chance of this preliminary refresher at his own machine.

The 'rocker' is then covered with stiff rubber. This has to be cut to size from a large sheet. This is quite a stiff job and a useful one for a man reaccustoming himself to strong grip and controlled powerful movement involving the whole body. (One patient who found it very useful was a man whose finger had been amputated after an accident with a machine in the printing works where he was employed. His job involved cutting layers of boarding with a knife and for a week or two before his return to work he spent his treatment time cutting out these rubbers.)

The rubber must then be nailed on to the 'rocker'—a job calling for neat finger work, repetitive use of the hammer and a fairly high standard of workmanship. It provides a useful assessment for fitness for assembly work of a similar nature.

Finally the 'rocker' and sole must be assembled in a jig and screwed together, a repetitive movement suitable for treatment of patients with wrist fractures or weakness in the tool-gripping fingers.

The problems of the permanently disabled patient are a constant stimulus to the work treatment in the heavy workshop. Many of the aids devised for them are made there. A special room has been laid aside in which a wide range of useful gadgets to encourage personal independence in dressing, feeding, hygiene and other everyday activities are on view. Some of these are on the market but others are either adaptations of standard articles or have been devised and made in the department.



1. High chair for arthritis.
2. Pilot light for oven.
3. Safety belt.
4. Tin-opener to operate with one hand.
5. Easy-grip oven tongs.
6. Sling track.
7. Swinging tap with lever handles.
8. Rotating shelves.
9. Universal grip for grater, mincer, potato-peeler, whisk.
10. Pull-out board for holding bowl and tin steady.
11. Walking-trolley (with ramp).

FIG. 7. Kitchen unit for training disabled housewives in the occupational therapy department of King's College Hospital. Dimensions 11 by 6 feet.

There is, for example, an aid to pulling on stockings for a woman with stiff joints and limited bending power. It consists of a metal frame attached to a wooden handle from which projects a shoe horn. The bending of the frame to the required shape is often done by paraplegic patients. Since a paraplegic cannot use the lower part of his body, and is confined to a wheel-chair, he has to develop as much strength as possible from the waist up, and such a job can help this development a great deal. The handle of this stocking puller-on is turned on a treadle lathe—another good job for anyone recovering from foot, knee and hip injuries. The handles are polished by some of the patients with chronic disorders, for whom such a simple, repetitive but productive job is ideal.

A very simple kitchen aid for the one-handed has been devised by the staff and is easily made. It consists of a wooden board, the under-side of which is fitted with two pegs to hold it steady on a table in which two holes have been made to receive the pegs. The top surface of the board has long stainless nails driven in, on which anything needing to be cut can be speared and held steady.

For spastic patients an angled feeding spoon with a large gripping surface can mean all the difference between feeding themselves and having to be fed. Such spoons are easily made by bending the handle of an ordinary spoon to the required angle and fitting it into a wooden handle which can be turned on the workshop lathe. Another aid for spastics, and for anyone liable to uncontrolled movements, is a metal attachment made to clip on to a plate so that food will not be pushed over the edge. This is made from an ordinary metal dish cover.

In all there are over sixty such aids and gadgets either on view or listed and illustrated in folders. New ideas are always in demand. If any readers of DISCOVERY feel that their own experience has led them to a useful solution of a problem encountered by disabled people in carrying out daily activities the occupational therapists at King's College Hospital will be glad to hear from them.

MODERN ADVANCES IN LUBRICATION

E. G. ELLIS
B. Sc., F. Inst. Pet.

Long before the invention of the wheel and axle, mankind must have known that lubrication of sliding surfaces eased their relative motion. When the earliest machines did appear, the need for the provision of lubricants to the moving parts was already appreciated and suitable substances were found.

The available material was limited, If we exclude solids such as graphite and talc, they must, in the main, have been the easily obtained animal fats; indeed up to the end of the 19th century suet was used for the bearings of rolling mills and the later, soap-thickened greases known for some time after as 'Suet Compounds'. The employment of the vegetable oils would naturally presuppose that methods of extraction or expression had been developed.

FATTY OILS AND GREASES

For hundreds of years the predominating mechanisms were the wheels and axles of waggon and carriage. Even the growth of the railways made little difference here and records of axle compounds show them to be composed almost exclusively of tallow, palm and whale oil. A revolutionary change occurred when soap was first introduced into these mixtures. This enabled quite large quantities of water to be incorporated in the form of a solid emulsion: cost was reduced and the properties of the lubricant modified.

To this day large numbers of private owner's waggons of the older type are lubricated with such compounds and almost up to the outbreak of World War II the official specification of the Railway Clearing House reads: "The grease to be an emulsified mixture of water, soda soap, neutral tallow or other suitable fat, *with or without mineral oil*. It must be free from rosin or tar oil, lime, gypsum or other filling matter and must not contain more than 50% of water."

Rosin oil must have been excluded on account of its sticky nature as some earlier manufacturers used to incorporate it in fatty oils to increase the viscosity. These so-called 'Cohesive Oils' were claimed to give longer service and thus to reduce costs. In the form of the lime soap however, rosin oil was used to make axle greases of another type altogether; and is still used today.

The lubrication mechanism of the emulsified axle greases is very simple. This type of grease is packed into a box over the journal with which it communicates by means of a hole. Starting up from the cold there will be little or no lubrication and so the temperature rises due to frictional heat. By specification these greases have a low melting point (between 110° and 140° F.) and the transmitted heat soon melts some of the grease which flows into the bearing. Friction is reduced, the temperature drops and the grease flow ceases. When all the lubricant in the bearing is used up, the cycle starts all over again.

The general use of fatty oils and crude greases continued until well into the first decade of the 20th century and, although by then mineral oils were being produced in quantity, the fatty oils were still preferred when any particularly onerous or special duty was involved.

This belief in the indispensability of fatty oil was still held by British railway companies until right up to and during the early part of World War II. With one exception they all insisted on a proportion—up to 25%—of either rapeseed or even olive oil in their axle oils. The shortage of glycerides (which are potential foodstuff) forced a review of the situation and they were either cut out altogether or replaced by a small percentage of fatty acids thus, to some extent, carrying on the tradition and providing oils which adequately performed what was, in effect, by no means a very difficult service.

While all these early mixtures appear to be crude and to lack the chemical stability and physical properties which we regard as essential today, it must be admitted that the wheels kept on turning, and bigger and better machines continued to be invented and produced. It might be true to say that engineering progressed *despite* the lack of scientific approach in the petroleum industry: for in general such an approach did not materialise until sometime between 1910 and 1920.

THE INFLUENCE OF THE PETROL ENGINE

The stimulus which literally changed the nature of the petroleum industry was, without any doubt, the invention of the internal combustion engine, and even more so, its rapid development during the 1914–1918 war. This led primarily to a demand for more efficient fuels which, for its fulfilment, required a far greater knowledge of the chemical nature of the lighter fractions than existed at that time. Fundamental study of this kind soon spread to other hydrocarbon bodies including those from which the majority of modern lubricating oils are made.

The most important type of engine, particularly during the war, was the aircraft engine, and by the very nature of its service the demand was for maximum efficiency and reliability. In the early days the aero-engines were relatively low-powered—Blériot was upheld during his lighthearted flight of 1909 over the Channel by a 25 h.p. Anzani—but they rapidly grew until, by the outbreak of the war, 100 h.p. was a normal figure.

Speeds, temperatures, fuel contamination and general design soon necessitated care in the choice of lubricant. The famous 100 h.p. Gnome rotary engine consumed about a pint of oil for every six miles of flying and would only perform satisfactorily when copiously dosed with pure castor oil—an oil incidentally which was used for aircraft engines in large quantities throughout that war and preferred for motor and motor-cycle racing for many years after. Indeed the hallmark of motor-cycle efficiency among young men in the immediate postwar years was the characteristic reek of the exhaust which was due to the castor oil.

While the choice of this particular glyceride was probably quite empirical, it must have been influenced by certain

factors. One of them may have been economic. The Gnome was a French design and in those days France had little mineral oil—none at all during the war. Again these early rotary engines were characterised by high frictional resistance and, under these conditions, a thick fatty oil would be a good lubricant.

Castor oil however, is quite different from the other fatty oils in two important respects. Its viscosity is some ten times greater and—an important point in an aircraft lubricant—it has a much lower freezing point.

Provided that a thick film of lubricant can be maintained between the moving surfaces, as should be the case in a properly designed bearing, the most important physical property of an oil is its viscosity. It was not for some years after the war that this fact received popular recognition among users. This was when the American Society of Automobile Engineers first published their general classification. These 'S.A.E. Numbers' are solely concerned with viscosity, and particularly at the higher temperature levels at which the oil has to operate in the engine. Today for the lighter-bodied and winter grades the classification has been extended and limits are now set which correspond to starting temperatures in the coldest parts of the American continent.

To give some idea of the magnitude of the various viscosity levels the following table—which gives very approximate values at room temperature compared to water—may be of use.

Petrol	0·6
Water	1·0
Burning Oil	2·0
Olive Oil	85·0
S.A.E. 10 Winter	100·0
S.A.E. 20	200·0
S.A.E. 30	500·0
Castor Oil	1000·0
Glycerin	1500·0
Bitumen	30,000,000,000·0

TABLE 1. RELATIVE VISCOSITY VALUES

Oils become thinner as they are heated and the amount by which this happens varies considerably between oils of different origin. The natural glycerides are superior in this respect to the petroleum fractions. Other things being equal, an oil which shows the least change is to be preferred.

There is an empirical method of comparing the viscosity/temperature characteristics, long used in the industry, which is called the 'Viscosity Index' or V.I. for short. Those possessing the best V.I. (i.e. least change with temperature) have been given the arbitary figure of 100 and those with the worst, 0. (This is somewhat of an oversimplification today as lubricants exist which have an index higher than 100 and below 0.) Normal motor oils of good quality will usually be of the order of V.I. 90 or so.

The V.I. of your motor oil does effect consumption to some extent and the figures given in the Table below have been quoted for a thin winter motor oil, an S.A.E. 10W.

V.I.	*Relative Oil Consumption, miles per gallon*
130	1450 to 2100
120	1250 to 1750
100	1100 to 1250
75	1000
0	900 to 700

TABLE 2. OIL CONSUMPTION AND VISCOSITY INDEX

Fig. 1 indicates the magnitude of the viscosity differences between different oils, and how the viscosity of the particular oils varies with temperature.

It has long been known that lubricating oil fractions from certain types of crude petroleum have better V.I.'s than those from others. The best came from Pennsylvania—a name in the industry comparable to Virginia in the tobacco world. These oils are predominatingly paraffinic in character and, as well as having good viscosity/temperature features, they have a high resistance to the oxidation which gives rise to coking and sludging troubles. Unfortunately these desirable properties are to some extent offset by the fact that the paraffinic oils set solid at relatively high temperatures because of the presence of solid wax which forms structures which prevent flow under the natural head of the oil: an important point both in dispensing and storage. The temperature at which this takes place is known as the 'Pour Point' of the oil, and this provides one of the many empirical tests used in lubricant laboratories. To improve the Pour Point of the paraffinic distillates recourse was had to relatively costly operations of de-waxing which involves the use of selected solvents at low temperatures.

One of the first fruits of the more scientific approach in the lubricant industry was an important application of physical chemistry to this particular problem. Round about 1930, it was found that certain synthetic chemicals of high surface activity when added in minute proportions to paraffinic (and other) oils produced a pronounced lowering of the Pour Point. This was due to the action of the chemical in preventing the aggregation of the wax crystals and, although these chemicals were relatively dear, they provided a much cheaper alternative to conventional dewaxing. The effect is clearly illustrated in Fig. 3 which refers to the action of a well-known proprietary brand of Pour Point depressant.

THE ADDITIVE AGE

This principle of adding a small quantity of synthetic organic chemicals to the oil in order to produce significant changes in its physical and chemical properties heralded a new phase, and qualitatively it changed the normal oil-blending technique to the ultimate benefit of the user. Without too great a stretch of the imagination it may be compared to the practice of alloying steel in order to produce new varieties of special character. Just as it is possible to increase the hardness or corrosion-resistance of the metal, so is it possible to increase the V.I. of a mineral oil or to reduce its susceptibility to oxidation.

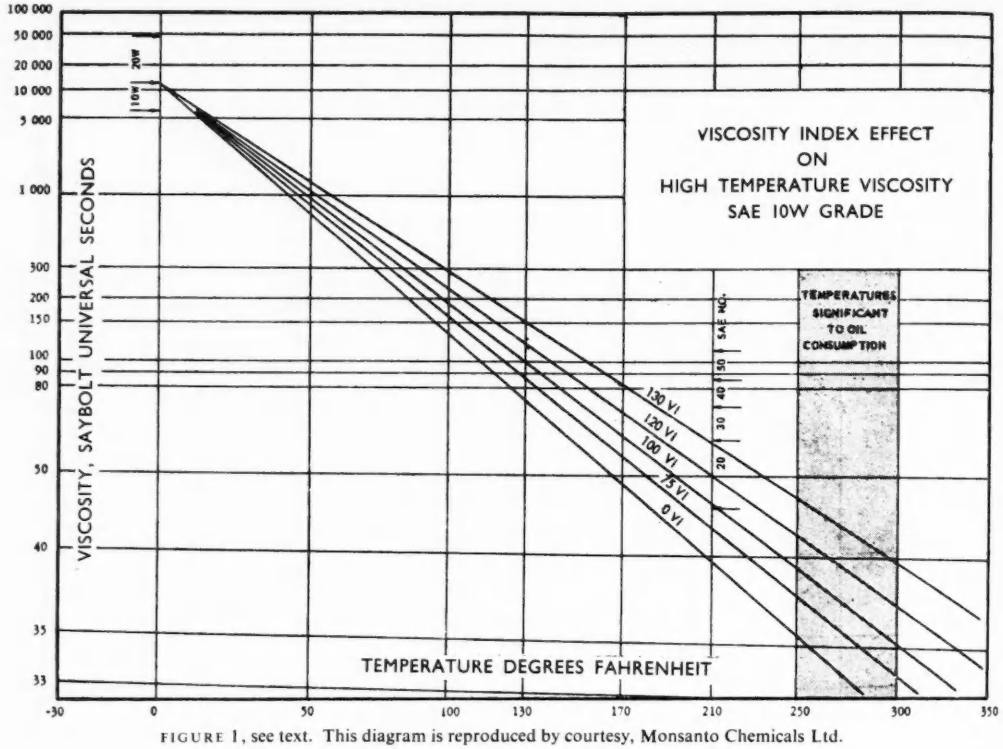


FIGURE 1, see text. This diagram is reproduced by courtesy, Monsanto Chemicals Ltd.

The Pour Point depressants were the first of such additives, and they were quickly followed by others which fortified or improved the mineral oil base in those directions in which it lacked qualities more and more required as the speeds and loads of modern machinery increased. Within fifteen years the number of new patent applications per annum in the U.S.A. had increased by about twenty times.

A large number of patents have been devoted to oxidation resistance, particularly of crankcase oils. The earlier fatty lubricants while superior in friction-reducing properties compared with the straight mineral oils then available, rapidly broke down in use under the combined influence of heat and oxygen and produced copious deposits of carbon. Selected mineral oil stocks were much more resistant, but they also had a tendency to deteriorate ultimately in a similar manner.

Study of the oxidation mechanism of pure hydrocarbons leads to the conclusion that it was essentially a chain reaction where the initiating chains were formed from unstable, oxygen-containing bodies; principally peroxides and hydro-peroxides.

It should therefore be possible to slow down the reaction by breaking the chains, and certain oil-soluble organic compounds will do this when blended with the mineral oil in quantities of less than 1%. Aromatic amines (e.g. phenyl α-naphthylamine) are effective, and also certain substituted cresols.

As in 1914, so once again in 1940 the demands of warfare resulted in engines being stressed to limits rarely encountered in peacetime. It soon became apparent that even the best available fortified lubricants were inadequate for the continuous running at, or near, peak loading which was a feature of wartime requirements, and various mechanical troubles occurred, including corrosion of bearings made of heat-resistant alloys. Gradually these faults were overcome, one by one, and the wartime heavy-duty oils (H.D. Oils) appeared.

The additive combinations used in them are now embodied—but in reduced quantities—in the much advertised lubricants sold to the ordinary motorist. Naturally the stringent usage conditions of the military engine are far removed from those of domestic motoring. (Indeed breakdown due to lubricant quality is, and always has been, a rarity in ordinary motoring.) The private user will therefore receive benefits from modern additive-treated lubricants on a reduced scale; he can, for example, be certain of a cleaner engine. This is due to the inclusion of another type of dope in addition to the usual anti-oxidant: the so-called 'detergents'. The name has been coined by reason of this improved cleanliness, although in fact these bodies are peptisers and prevent the fine carbon—derived from the fuel—from being deposited in those areas where its presence would interfere with the efficient performance of the engine. The effect of these additives, usually in conjunction with the anti-oxidants, is quite positive and an

FIG. 2. Pistons from Test Engine, using respectively straight Mineral Oil (*right*) and Additive-treated Oil (*left*).

excellent example of the action, taken from a test engine, is shown in the photograph (Fig. 2).

The design of the modern engine and the efficiency of the machining and fitting are such that friction is reduced to a minimum. Even those areas where boundary conditions—where it is not possible to maintain a thick film of lubricant—exist are catered for metallurgically to a very large extent. Therefore the problem of making lubricants which have these extra pressure (E.P.) properties is, in the main, confined to gear oils and the various fluids used in metal-forming operations.

The discovery of compounds that give this property to mineral oils goes back many years. Some of the 19th-century formulae are quite alchemical, almost necromantic, but it is quite remarkable the number that contain two elements which are active in this way: sulphur and lead, The latter readily forms an oil-soluble soap while the former, when not combined in the molecule as say, dibenzyl disulphide, is easily incorporated in fatty oil by simple heating.

A purely empirical approach to this problem persisted for many years and indeed it was not until the quite recent work of Bowden, Finch and fellow workers revealed the true nature of the rubbing surfaces that the action of the E.P. compounds was understood.

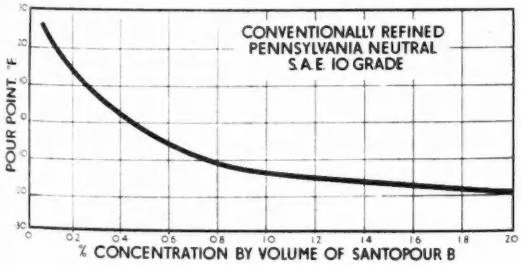


FIG. 3. Effect of addition of Pour Point Depressant. (*Courtesy, Monsanto Chemicals Ltd.*)

To be successful the lubricant must react chemically with the surface. For example, in the experimental work of Bowden's group working at Cambridge it was shown that fatty acids applied to unreactive metals such as platinum, even when they were well adsorbed, were of little more value than saturated hydrocarbons and did not lubricate above their melting points.

On reactive metals they became good boundary lubricants and effective up to the melting point of the corresponding soap. This is understandable when it is realised that the lateral adhesion between the molecules of a lubricant is equally important as their attachment to the surface. Hence *solid* films are the most efficient. At the melting point the film expands and the lateral adhesion falls to a low value and this means increased friction and metallic seizure.

In a similar manner sulphur in such compounds as the sulphurised fatty oils forms sulphide films which, over a critical thickness, provides efficient lubricants. The action is sometimes, however, much more complex, for there exist many organic sulphur compounds, widely used as E.P. additives, which do not form metallic sulphides. Among them are certain sulphonic and mercapto acids; α-mercapto-palmitic acid, for example, is a good boundary lubricant, but it appears that its action is analogous to that of the fatty acids, leading to the formation of complex soaps.

Thus it might be said that the only real test of a lubricant is the service it gives in practice, this is difficult to apply to development work. Some shorter way must be found in which service conditions may be simulated to one extent or another. Several test machines have been designed for the E.P. oils and a considerable amount of work has been done with them. The moving surfaces are all so made as to produce conditions where only boundary lubrication is

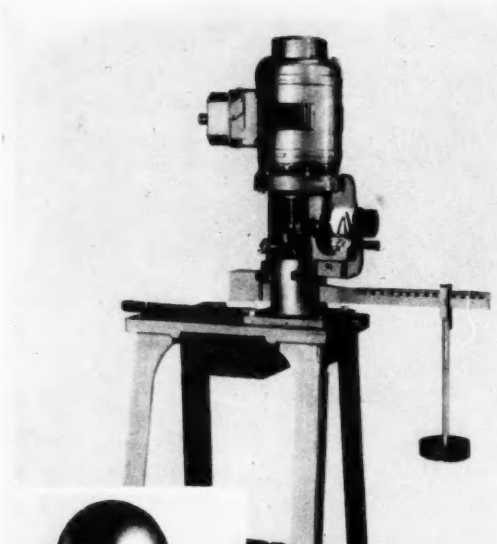


FIG. 4. Shell Four Ball E.P. Tester. FIG. 5 (*inset*). Balls welded together due to lubricant failure.

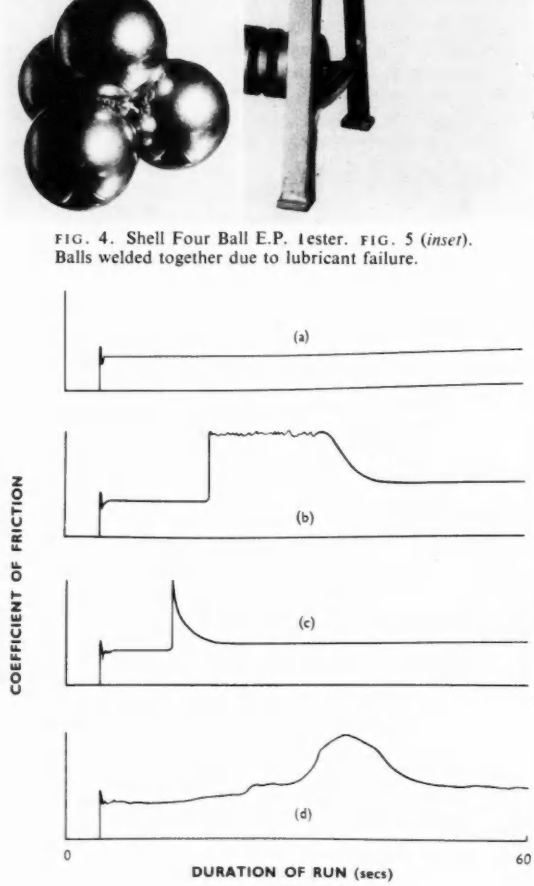


FIGURE 6.

possible. In one a spindle is rotated between two loaded bearings in the form of V-shaped slots so that only line contact is made and the resultant pressure very high. There are others, but the one illustrated here, the Shell Four Ball machine has been chosen mainly because some quite fundamental work has been done with this apparatus. The design is simple and interesting and sliding motion under high pressure is produced between half-inch steel balls. The three bottom ones are held stationary while the upper one, attached to a spindle, rotates in contact with them, the necessary pressure being produced by a lever system. The photo (Fig. 5) shows them welded together due to lubricant failure and the machine itself is illustrated in Fig. 4. Characteristic friction diagrams (as in Fig. 6) are produced.

The position with regard to testing engine oils is much less satisfactory. Although there are many existing tests for the measurement of the oxidation resistance of mineral oils, and potential corrosive action on specific metals may also be checked in the laboratory, it has not yet been possible to forecast, with any accuracy, the probable behaviour of additive-treated engine oils under running conditions. This to a very large extent is due to the contamination by fuel and its combustion products which occurs rapidly in practice.

Up to now the problem has had to be solved by the use of test engines run in the laboratory under controlled conditions which represent arduous service and, as such, are likely to reveal any faults in the oil within a reasonable time. The oils themselves are rated on either a go or no go basis—as when run to produce ring-sticking within a specified time—or assessed on the condition of the engine parts. The tests which are used at the moment to qualify an oil for Service use are run in American engines, mainly because this type of testing had its origin in those evolved by certain engine builders in that country prior to the war, and secondly because of wartime co-operation.

All such tests have been criticised, it being said that they cannot be representative of British usage and that, in any case, they bear little relationship to the conditions of ordinary motoring. It must also be admitted that they are expensive to carry out, trained operators are required and the ancillary apparatus—dynamometers and the like—are costly. As an example it has been estimated that the cost of one run using the standard Chevrolet test is in the neighbourhood of £70; fuel alone costs £30.

Thus such work is confined to the laboratories of large concerns or government departments. Considerable discussion has taken place on the necessity of providing a simpler engine and shorter tests but the real solution can only come by greater knowledge of the physical and chemical problems involved.

READING LIST

Bowden, F. P., and Tabor, D. *Friction and Lubrication of Solids.* Oxford University Press, 1951.

Ellis, E. G. *Lubricant Testing.* Scientific Publications, Wellington 1953.

Finch, G. I. "The Sliding Surface." *Proc. Phys. Soc. B.* **63**, 465, (1950).

Nash, A. W., and Bowen, A. R. *Principles and Practice of Lubrication.* Chapman and Hall, 1937.

SCIENCE CONQUERS THE 90-MILE 'DESERT'

JOHN LOUGHLIN

A carpet of clover pastures, furrowed fields, grain crops and new farm blocks is rolling out over a barren wilderness in southern Australia.

One of Australia's most spectacular land development projects is conquering the notorious 90-mile 'desert'—a 6,000,000-acre expanse of despised wasteland that has resisted all other efforts at cultivation for over a century. It is yielding now to revolutionary land-use methods based on fertility-building 'trace' elements and a new agricultural and pastoral region is being brought into existence.

The creation of prosperous farms on an expanse of country long ago abandoned as hopeless is being watched by other countries with great interest, because it is demonstrating on a big scale how recent discoveries in the use of 'trace' minerals can be exploited to make good vital soil deficiencies.

In Australia there are many millions of a res of impoverished land—apart from the third of the continent classed as arid semi-desert—capable of being reclaimed for food and wool-growing. Science has shown that their only malady is mineral deficiency, that relatively minute quantities of minerals will turn dreary 'starvation' country into useful farmlands.

Striking results are being achieved in Australia by the use of zinc, copper, manganese and molybdenum, applied to the soil with superphosphate, singly or in mixtures, according to the particular types of soil. The main field of operations at present is on the well-watered but sparsely settled plains of south-eastern South Australia and the border areas of neighbouring Victoria. Here gnarled and stunted Mallee timber, yacca grass trees and harsh broom and tea-tree scrub tell eloquently of the poverty of the soil. When it was discovered that the soil was responsive to the new methods, settlers began to move into the 'desert', sandy scrubland formerly worth 10*s.* an acre soared in price. But failure was inevitable for some. It takes time and money to lift the spell from this lifeless country, to free it from the grip of sterility, to revitalise the life forces in it.

Behind the land development project are the resources of a big organisation—the Australian Mutual Provident Society, the most powerful mutual life assurance society in the British Commonwealth. It is employing its capital, allied to science, in the reclamation of 750,000 acres, to be parcelled up into 800–1000-acre farm lots and handed over to selected young farmers.

One 500,000-acre tract is in South Australia, while another holding of 250,000 acres awaits development in the State of Victoria. The project is on the way towards its target of "a farm a fortnight". The great sleeping giant is stirring as the 'trace' minerals set the natural fertility-building processes in motion. Mixed pastures are flourishing in the midst of the scrublands. Well-nourished sheep and beef and dairy cattle are already grazing on them. You see the first fruits of the project close to the headquarters established at Brecon, ten miles off the inter-capital highway between Adelaide and Melbourne. A small settlement of prefabricated houses, workshops and stores has sprung up around the old homestead at Brecon, which takes its name from a Welsh village—the birthplace of an early owner. When operations are in full gear the Society will be putting between twenty and thirty young farmers on their own farms each year. The farms will be complete with homes, established pastures, fencing and stock. They will be capable of carrying from one to two sheep to the acre, plus cattle. The properties will be financed by the Society on terms that will give the new settlers every prospect of success.

These farmers have living-quarters at Brecon, but in order to cram as much work as possible into the daylight hours, they choose to live on the job with their machines and return to the settlement only at week-ends. Most are under thirty, veterans of the Second World War with some farming background. They have to spend five years on general development work, and as the scheme did not begin until 1949, no farms are yet ready to be handed over. The five-year wait is dictated by the time needed to establish pastures and bring the farms to an economical working basis.

The array of heavy machinery assembled on the project shows graphically why plenty of capital is essential for a 90-mile plains venture. In addition to extremely rugged transport, the main units employed are wheeled and crawler tractors ranging from 35 to 135 h.p. Some of them form part of the equipment Australia has been buying under a 100,000,000-dollar loan received from the International Bank for national development.

* * *

You see the 135 h.p. giant Diesels bucking and roaring across the undulating plains, flattening the virgin scrub and tearing out the Malee. Two 50-foot logs coupled together and dragged by ship's anchor chains behind one of the most powerful tractors smash a 100-foot swathe in the scrub and trees like a reaper going through a crop. Next follow the tractor-drawn disc ploughs—two big eight-furrow Majestic ploughs in tandem. They turn over 30 acres of the grey and white soil a day, carving out roots and mincing up the vegetation. For several months the land lies fallow. Then it is reworked with smaller disc ploughs to receive the superphosphate and 'trace' minerals—in this case copper and zinc together—and for seed sowing.

Although the long unproductive period between the initial heavy capital expenditure on plant and the first pay-off may deter the prudent settler without much capital, the 90-mile enterprise is by no means a monopoly of the

FIG. 1. Typical scrub country in the 90-mile 'desert.'

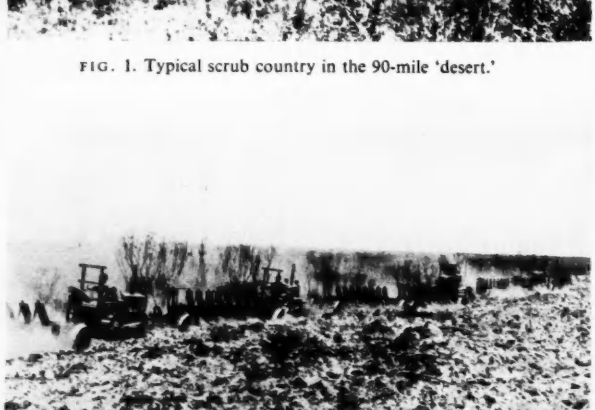


FIG. 2. Disc ploughs, tandem-hutched to give maximum results, churn up the soil which science has at last managed to tame.

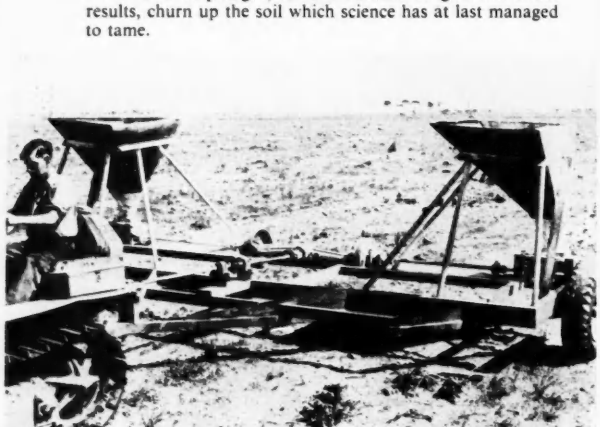
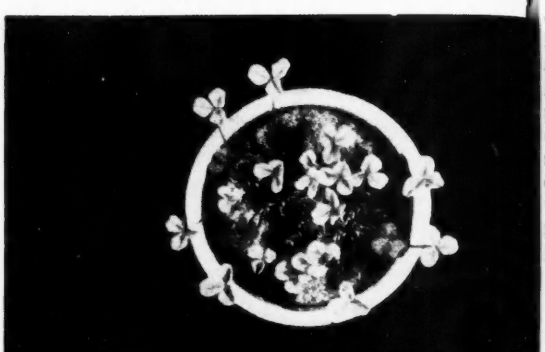
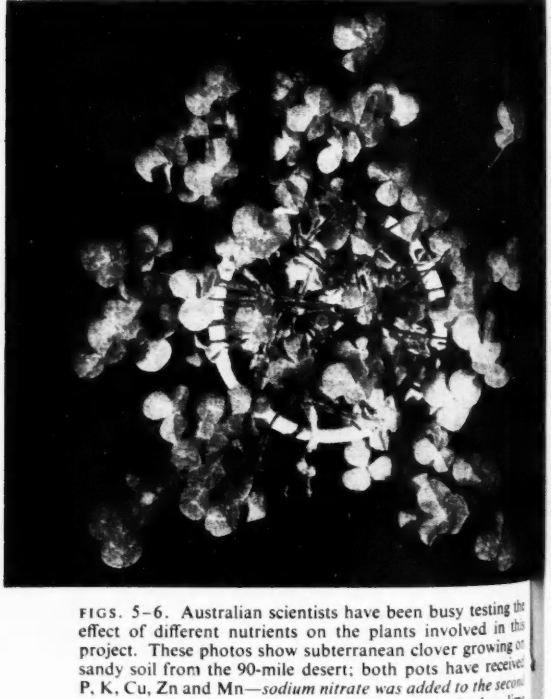


FIG. 3. Months later the soil is reworked with smaller disc ploughs to receive the superphosphate and 'trace' minerals. Here, a spreader is distributing the superphosphate.

FIG. 4. Hay-making on a former wilderness, which can now maintain sheep and cattle.





FIGS. 5–6. Australian scientists have been busy testing the effect of different nutrients on the plants involved in this project. These photos show subterranean clover growing on sandy soil from the 90-mile desert; both pots have received P, K, Cu, Zn and Mn—*sodium nitrate was added to the second pot at seeding.* Equally healthy growth resulted when lime was added *instead of* nitrate.

A.M.P. Society. Several settlers with sufficient financial backing have been developing holdings since the first successful experiments with zinc and copper.

Mr. Keith E. Becker, an Adelaide man, took up 11 square miles of desert land when he retired from the Adelaide College of Music in 1941. He poured superphosphate into the soil and sowed wheat and oats. The only result was sparse, spindly crops with under-developed grain. Becker was not the first optimist to fail in this region of abandoned properties, deserted homesteads and heartbreak. He invited scientists of the Commonwealth Scientific and Industrial Research Organisation (which is a Federal Government organisation) to use his properties for long-range tests and investigations. Research extending over several years on experimental plots established on Becker's property finally produced the verdict that copper and zinc were the key to productivity on the 90-mile plain. Becker began to apply this scientific knowledge to his property. He sold some of his holding and concentrated on clearing 3000 acres on which he established pastures and subterranean clover. While other settlers have raised grain crops or stock, Becker has grown subterranean clover, which is so valuable for wool-growing, and South African perennial veldt grass for seed. He has become the major producer of clover and veldt grass seed in South Australia.

* * *

The purchaser of part of Becker's holding was Mr. Murray Thomas, a South Australian stud sheep breeder. Having founded a strikingly successful sheep stud on the reclaimed desert land, he is raising subterranean clover, veldt grass and phalaris pastures, and grain crops, on about 2000 acres. With £10,000 worth of heavy plant he is harnessing the balance of his scrub property. His merino sheep are thriving. Their wool is bringing high prices at the Adelaide sales.

These successful early ventures, already well under way when the A.M.P. project came into the field, testify dramatically to the efficacy of the soil-building techniques worked out by the research men.

The solution of the 90-mile desert mystery stemmed from an idea that linked two apparently unrelated lines of scientific research. C.S.I.R.O. investigators were working simultaneously with scientists of other countries in the 'thirties on the use of 'trace' elements. But they had not reached the stage of considering how or where minerals could be put into practical use on particular Australian areas of low fertility.

About that time another group of C.S.I.R.O. scientists were trying to find the cause of 'coast disease', an ailment that had seriously hampered the sheep industry on the sandy coastal areas of South Australia and parts of the State of Western Australia. Sheep raised on 'coasty' country wasted away, their wool lost its crimp and became wiry, and in the bad areas whole flocks were lost. The C.S.I.R.O. established an experimental station at Robe, South Australia, and made exhaustive investigations into the disease. By a process of elimination the scientists concluded that a diet deficiency was behind the disease, but as it occurred on good pastures as well as poor, the cause of the deficiency was obscure. Eventually they found that sheep needed a trace of cobalt in their diet. A minute dose—as little as one 300,000th of an ounce—made all the difference between a healthy animal and an ailing one; without it they were liable to develop anemia. It was also discovered that the coastal pastures were not supplying the sheep with the small amount of copper they needed to grow healthy wool. So cobalt was administered to the sheep as a drench, and copper was supplied in the fodder.

* * *

Following up these clues scientists made trial applications of copper to pasture plots. The immediate response by the pasture confirmed the deficiency of copper in the soil. These tests showed that the soil required copper, with the normal dressing of superphosphate, and that the sheep required cobalt and copper. At this stage it struck research workers that they might also have found the answer to the century-old mystery of the 90-mile desert. Mr. D. S. Riceman, who with Mr. A. J. Anderson was assigned the task of testing the theory, wrote in an account of his work that the soils of the region were mainly leached siliceous sands, extremely low in phosphorus and nitrogen. Although they were in an area with an average rainfall of between 15 and 20 inches, the Mallee and native vegetation was dwarfed and the productivity of crops sown was poor.

During 1944–6, Riceman with another assistant, Mr. J. K. Powie, conducted soil tests on more than 1000 plots in the Keith district. Each plot was sown with varying amounts of seed, fertiliser and trace minerals. The chief problem was to find out how to set the natural regenerative processes of the soil to work by establishing leguminous pastures such as clover and lucerne (alfalfa) crops. Legumes, in partnership with the *Rhizobium* bacteria, 'fix' nitrogen from the atmosphere and so increase the fertility of the soil. All earlier efforts to establish legumes on the desert had been ineffective.

Riceman established that clover thrived on soil supplied with both zinc and copper. Lucerne needed copper but not zinc; oats, zinc but not copper. Fairly heavy dressings of superphosphate were necessary for all growth. Standard practice now is to give the soil a 'cocktail' dressing of seven pounds of copper sulphate and seven pounds of zinc sulphate to the acre—at a cost of only seven shillings—in addition to 187 pounds of superphosphate. No more copper and zinc need be applied for at least six years. Experience has shown that a proper balance of pastures must be maintained. Subterranean clover, S. African veldt grass, phalaris grass and lucerne form the pastures, but deep and shallow rooting types only can be grown together. Lucerne and phalaris are both deep rooting and do not grow well together. Shallow rooting subterranean clover and veldt grass do not partner well.

In the widest sense, the 90-mile desert scheme is an important laboratory experiment in settlement and land utilisation principles. In the local Australian sense it is a major project ushering in a promising era of land development, and bringing thousands of square miles of abandoned land within the scope of agriculture and wool-growing.

READING LIST

The following Bulletins of the Australian Council for Scientific and Industrial Research deal with the scientific aspects of this 'reclamation' prospect: Nos. 234, 249 and 266.

THE BOOKSHELF

William Herschel by J. B. Sidgwick (*London, Faber & Faber, 1953, 228 pp., 12s. 6d.*)

This book is one of a series of biographies which range in subject from Thomas Becket to Florence Nightingale. In any list of the distinguished, Sir William Herschel deserves a high place, and here we have an expert evaluation of his work. Few men have done more in their day to advance the frontiers of knowledge, and it is interesting to see that Mr. Sidgwick rates him more highly than his equally famous son, Sir John Herschel, who was Senior Wrangler at Cambridge and a Fellow of the Royal Society at the age of twenty-one.

William Herschel was the inspired amateur—the musician who became astronomer because he could not help himself, and maker of first-class telescopes because only by the skill of his own hands could he get instruments good enough for his purpose. The thousands of hours spent in casting and figuring his mirrors of speculum metal are in themselves an epic, to be matched alone by the devotion of his sister Caroline, who gave up her life to helping him, and richly merited the distinction of being made an honorary member of the Royal Astronomical Society at a time when membership was confined to men.

In lay circles Herschel is remembered chiefly as the discoverer of Uranus, which at first he mistook for a comet. Astronomically this was not very important, for it was an accidental find and in no way comparable with the systematic tracking-down and detection of Neptune sixty-five years later. But it caused a sensation by reason of its novelty; five planets had been known in the sky since the dawn of history, and it had occurred to no one that there might be more. To Herschel himself it brought immediate and widespread fame, and enabled him, through the interest taken by the Royal family, to give himself in the future wholly to astronomy.

Like all astronomers of the eighteenth century, Herschel was much concerned with the solar system. But the exceptional space-penetrating powers of his telescopes led him to a most thorough scrutiny of the stellar system, and brought him to the conception of stars aggregated into galaxies—so-called, of course, from the Milky Way which marks out the rim of our own particular 'island universe'. This cosmology was new, and from the vistas that it opened up Herschel earned the epitaph inscribed in the church of Upton, near Slough: *Coelorum perrupit claustra*—"He broke through the barriers of the skies."

As a result of Herschel's labours—and his labours were truly Herculean—astronomy took a great leap forward. Horizons were widened immeasurably, although the immense aid of the spectroscope and of photography was not to be available until long after his death. Nor was it yet possible to determine any stellar distances, and so to arrive at the scale of the universe in quantitative terms. Herschel did literally, however, open men's eyes to the wonders that awaited exploration, and Mr. Sidgwick succeeds in showing clearly, in a most readable narrative, how great his stature was.

E. N. PARKER

The Nature and Structure of Collagen edited by J. T. Randall (*London, Butterworth's Scientific Publications, 1953, 292 pp., 42s.*)

This small volume is a record of the papers and discussion at a meeting organised by the Colloid and Biophysics Committee of the Faraday Society which was held earlier this year at the Wheatstone Physics Laboratory of King's College.

It covers a considerable field in, as the editor admits, a rather patchwork fashion. The earlier papers deal with the histology of connective tissue and its derivatives, with reticulin, with collagenase and with connective tissue antigens. Subsequent papers deal with the change of collagen with age, its derivatives (e.g. gelatin), its amino acids and its physical properties. Other papers record the differences between various types of collagen found in different organs and tissues, X-ray diffraction studies of collagen, the significance of chondroitin sulphuric acid and the physical and chemical problems involved in fibre formation and structure. A certain amount of discussion follows each group of papers and there is no doubt that this, together with the papers, results in a volume which is a most valuable compendium of information.

There is an adequate bibliography and subject index which add substantially to the value of the book.

G. H. BOURNE

The Natural History of Infectious Disease by Sir Macfarlane Burnet (*London, Cambridge University Press, 2nd Edn., 1953, 356 pp., 22s. 6d.*)

While this book will prove of immense value to the doctor, the medical scientist and the biologist, it is also of great interest to the intelligent layman. The first edition appeared in 1940 with the title *Biological Aspects of Infectious Disease*. The second edition contains much new material, the original text having been thoroughly revised in order to include the great discoveries made since 1936 in the prevention and cure of many infectious diseases. Indeed it would be true to say that we have come to what is practically the end of the greatest social revolution in history by the virtual elimination of infectious diseases as a significant factor in our present social life.

In the last twenty years there has also been a parallel interest in the nature of the micro-organisms responsible for disease, and no class of scientist has come to the fore in this field more prominently than the Biochemist. It might be said that the biological sciences could be divided into two main groups: those concerned with the structure and function of living organisms, and those sciences which deal with the interaction of organisms within their environment and especially with other organisms either of their own or different species within that environment.

This volume, like its predecessor, follows the ecological approach to the problem of infectious disease. This probably represents one of the most fundamental changes of attitude by the scientist in the last two or three decades. In recent years, ecology as a scientific study has advanced mainly because of human needs. It is therefore the job of the trained ecologist to provide the knowledge which will preserve a satisfactory balance of nature. It is this theme in its relation to infectious disease which runs through this book.

The control of infectious disease is one of the greatest success stories of modern science, and this book deals admirably and very fully with the subject. It is lucidly written and contains many interesting examples to illustrate the various points at issue. It is a noteworthy addition to social science by the present Director of the Walter and Eliza Hall Institute for Medical Research in Melbourne.

HARRY HOGGAN

Chromatographic Methods of Inorganic Analysis by F. H. Pollard and J. F. W. McOmie (*London, Butterworth's Scientific Publications, 1953, 192 pp., 30s.*)

It is a measure of the rate at which chromatography has developed in the last decade that a book of substantial size, quoting some hundreds of references, can now be written which deals with only a relatively small part of the subject.

Although inorganic paper chromatography—which forms the main subject of this book—is more than a century old, dating from pioneer experiments by Runge, Schoenbein, Goppelsroeder and others, its extensive application as a powerful modern method of analysis is comparatively recent. Several schools of study have grown up, notably in Belgium and Australia, and in this country at Teddington and Bristol; it is at the latter that the authors have pursued their studies.

This book seems to meet all the requirements for a good text-book. It is clearly written, comprehensive, well illustrated, critical and up to date so far as the time-lag entailed by passage through the press permits. The approach is highly practical and ample information is given for carrying out a very wide range of analyses, both quantitative and qualitative, without recourse to further literature. It contains many valuable hints, clearly born of much laboratory experience about technique and the construction of

simple ancillary apparatus. Two particularly useful features are the extensive tables of solvent mixtures suitable for the separation of various cations and the table of analytical reagents which have proved satisfactory for revealing the various zones of the chromatogram.

Two concluding chapters deal with inorganic chromatography on media other than cellulose, such as alumina or silica gel, and methods in which ionised substances are made to move by application of a potential difference.

This is an excellently conceived and produced book which can be very warmly recommended.

TREVOR I. WILLIAMS

Practical Chromatography by R. C. Brimley and F. C. Barrett; foreword by E. C. Bate-Smith (*London, Chapman & Hall, 1953, 128 pp., 15s.*)

During the last decade chromatography has come into such extensive use in almost all fields of chemical analysis that its importance no longer needs emphasising. This wide extension of its use has inevitably been accompanied by the growth of a vast and unwieldy literature scattered through scores of different journals. There is a corresponding need to reduce this to manageable proportions by means of reviews and books. The present publication, restricting itself to the laboratory practice of chromatography, will be useful to many workers. It contains much valuable information on techniques and apparatus for overcoming the difficulties constantly encountered in laboratory practice, and by consulting it both novices and established workers may save themselves much trouble; it ought therefore to be available for reference in all chemical laboratories in which chromatography is practised.

The scope of the book is, however, not quite as wide as its title suggests, for the emphasis tends, not unnaturally, to lie upon those fields of which the authors and their colleagues have extensive first-hand knowledge. Other fields, no less interesting and important, tend to have less attention than they deserve, making the text somewhat unbalanced. For example, inorganic paper chromatography, in which the Bristol school has played so notable a part, receives comparatively little attention.

The book concludes with a subject index and a list of more than a hundred references quoted in the text; in the absence of an author index it would have been helpful had this been ranged alphabetically. An appendix contains some miscellaneous details of solvents, sprays and R_F values.

TREVOR I. WILLIAMS

The Observer's Book of Common British Insects and Spiders by E. F. Linssen and L. Hugh Newman (*Frederick Warne, London, 1953, 128 pp., 64 plates. 5s.*)

This is a real *pocket* natural history book; it measures $5\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{4}$ in. and so can really be carried in the jacket pocket. It provides a brief introductory sketch of the external and internal anatomy of the insects, with some remarks on the significance of their coloration, and short accounts of each of the twenty-one orders of Insecta which are represented in Britain. Six pages at the end of the book contain an even more compact account of the British Spiders.

The information is of necessity very condensed; thus for example only one species of ant is mentioned, the Wood Ant (*Formica rufa*). But a surprisingly clear picture of the anatomy and behaviour of each of the main families within each order emerges despite the authors' rigorous selection of facts. These facts seem to be accurate and up-to-date, in all but a few cases.

Many of the plates are coloured and the quality of these plates is excellent. The purchaser will certainly obtain every farthingsworth of value out of the crown he pays for this book.

DEREK WRAGGE MORLEY

Absorption Towers by G. A. Morris and J. Jackson (*London, Butterworth's Scientific Publications, 1953, 159 pp., 30s.*)

This monograph is a logical successor to *Cooling Towers*, written by one of the present authors and already reviewed in DISCOVERY (Feb. 1952, p. 66). It continues the policy of Imperial Chemical Industries to organise the publication of their private design manuals for the benefit of industry as a whole. The approach, therefore, is entirely practical and results in a handbook for chemical engineers on the design and operation of absorption towers. Examples are worked out in detail on the basis of the two-film theory and, alternatively, from the concept of the height of a transfer unit. The types of packing available for constructing the equipment are described and methods of predicting their performance analysed. The whole volume is packed with practical detail, and anyone with a reasonable knowledge of chemistry could use it with advantage if faced with the problem of absorbing a gas from a mixture on more than a laboratory scale.

F. E. W.

Key to the Names of British Plants. By R. D. MacLeod. (*London, Pitman, 1952, 94 pp., 12s. 6d.*)

THE scientific names which biologists have given to plants and animals are largely derived from Latin or Greek words, and a knowledge of those two languages enables one to extract the full meaning out of names which may otherwise seem little more than tongue-twisting labels. This book is useful for finding out the derivation of the scientific names of British plants.

In some cases the scientific name is commemorative, and immortalises, for instance, a great botanist or patron of botany; here the entries given by Mr. Macleod are particularly interesting, especially as the historical details which he has included are otherwise not easily traced except in very large and expensive volumes. Occasionally one finds that an ancient myth has been preserved in a generic name. One example given by Mr. MacLeod is *Achillea*, the name of the genus including *A. millefolium*, or yarrow, from which chemists have recently extracted a blood-clotting compound; that discovery suggests that there was a grain of scientific truth in the old myth about Achilles finding that the plant had the power of stanching wounds. It was the myth which inspired the adoption of the name *Achillea*.

Many will welcome the appearance of this volume, in particular amateur botanists. When a new edition is prepared, it could with advantage include some indication of how the names are pronounced, as was done in Gilbert-Carter's *Glossary of the British Flora* (C.U.P., 1950).

How to Dowse by Marguerite Maury (*London, Bell, 1953, 184 pp., 11s. 6d.*)

The most astonishing thing about the whole of the material in this book is that the author believes it. Trained as a nurse, she married a homoeopathic doctor and founded the *Collège Radiesthésique Français*, which provides a correspondence course in radiesthesia, and there have been nearly a thousand takers so far. This course is the substance of the present book, so the title is a little misleading.

Radiesthesia is sensitiveness to radiation, a sensitiveness that, according to Mme. Maury, enables one, with the aid of a divining rod or a pendulum, not only to find underground water but also to locate iron deposits from maps, detect mis-mating in animals, predict the sex of embryo chicks, diagnose illness, and perform a number of other remarkable operations not taught in the schools or universities.

The essential characteristics of radiesthesia, she says, "are its variability, its uncertainty and its individual quality". Perhaps, in the absence of evidence that anyone trained in orthodox science will accept, we had better leave it at that.

C. L. BOLTZ

20th Century Chemistry by Joseph I. Routh (*Philadelphia & London, W. B. Saunders, 1953, 564 pp., 29s.*)

An exciting and up-to-date American book, which British science masters should examine for it mentions so many recent developments of significance. For example, there are $2\frac{1}{2}$ pages about nylon, while other items mentioned include catalytic cracking, freon, the cosmotron, and vitamin B_{12}, which have scarcely found their way into any comparable British books. The author is a biochemistry professor, and there is perhaps rather too much biochemistry in the book; this fact, coupled with the inevitable use of American spelling, makes it unsuitable for young British students, but otherwise it would be just the book to get them excited about the subject, for it brings out very effectively the importance of the chemist's contribution in modern society. The pictures deserve special praise, and this reviewer knows of no similar British book which is so well illustrated with really up-to-date pictures.

Far and Near

Antibiotics in Animal Feeding

Penicillin and aureomycin are now being included in animal feeding-stuffs, but such additions are not suitable for all types of stock and care must be taken in mixing and feeding. Farmers proposing to use antibiotics in livestock rations are advised to read the new Advisory Leaflet (No. 418, *Antibiotics in Livestock Feeding*, price 2d.) which has just been published by the Ministry. This document is based on knowledge gained from controlled experiments sponsored by the A.R.C. and carried out at research institutes, on N.A.A.S. Experimental Husbandry Farms and on commercial farms. Good results have been obtained with pigs and poultry (including chickens, goslings and turkey poults). Antibiotics do not so far appear to be of much—if any—value for ducklings being reared for the table. They should not be fed to either pig or poultry kept for breeding purposes.

There is no evidence to support the use of antibiotics in the rations of ordinary commercial layers, since birds do not come into production any earlier, nor do they lay more eggs as a result of the inclusion of antibiotics in their food.

There is some suggestion that antibiotics inhibit the growth of bacteria in the paunches of ruminant animals (cattle, sheep and goats), and for that reason they should not be used in the rations of such animals.

Mond Nickel Fellowships 1953

The Mond Nickel Fellowships Committee announce the following awards for 1953:

J. E. BENSON: of Metropolitan-Vickers Electrical Co. Ltd., Manchester; to study the technique and interpretation of results of non-destructive testing of metal components in the United Kingdom, on the Continent and in the U.S.A. and Canada.

K. BLACKBURN: of Dorman, Long & Co. Ltd., Redcar; to study hot-metal basic open-hearth practice in Great Britain, on the Continent and in the U.S.A. and Canada, with particular reference to mixer furnace operation, refractories, instrumentation and pitside practice.

N. B. PRATT: of Broken Hill Proprietary Co. Ltd., Newcastle, N.S.W.; to study the technical and economic aspects of recent advances in the erection and operation of integrated iron and steel works in Great Britain, on the Continent and in the U.S.A. and Canada.

The Klein Chair

A special wheel-chair was needed by the Canadian Department of Veterans' Affairs for 'quadriplegic' patients, that is paraplegics paralysed in all four limbs. To meet this difficult requirement, Mr. George J. Klein, of the Mechanical Engineering Division of Canada's National Research Council, has developed the Klein electric drive. This drive can be fitted easily to most standard types of collapsible wheel-chair. It uses a 24-volt storage battery and separate motors for each wheel. The control lever, on the arm of the chair, has a very light action and is either covered by the patient's wrist or wedged between two of his fingers. With very slight motions of the forearm he can control forward motion, reverse and steering.

The control lever is actually a tiny joy-stick and the chair will move in whatever direction the joy-stick is tilted. An easy way to demonstrate the control is to tie a piece of thread, about a yard long, to the joy-stick. When you pull on the thread, the chair will automatically follow you wherever you go. It can be steered either in long, gentle curves or 'turned on a dime'. The chair has only one speed—about 2½ miles per hour—and a moderate acceleration. The same control lever also serves as a highly efficient brake. It returns automatically to the neutral position when pressure is removed; when the chair is in neutral, inertia and friction bring it to a gentle stop. (If an emergency brake is ever needed, all the patient has to do is use the 'reverse'.)

The range is about 25 miles on a fully charged battery. The chair is primarily intended for indoor use in hospitals where the floors are quite smooth. However, on occasion it could be used out-of-doors on pavements or paved roads provided there are no curbs or steep grades to climb.

One of the quadriplegic patients at Sunnybrook Hospital, Cyril Hutchinson, got the feel of the control in a few minutes and was able to perform complicated manœuvres with little difficulty.

U.N. Bibliography on Atomic Energy: A New Supplement

The U.N. Secretariat has now released Supplement No. 2 of Volume I of its publication *An International Bibliography on Atomic Energy: Political, Economic and Social Aspects*. This continues the presentation of a selective, rather than exhaustive, bibliography of official publications, U.N. documents and important books and articles reflecting individual views and public discussions.

In the same series of continuous bibliographical listings in the atomic energy field, the U.N. Secretariat published in 1951, Volume II of the International Bibliography covering the scientific aspects of atomic energy and containing over 25,000 items. The first supplement of Volume II was published in 1952 and covered over 8000 items. The next supplement to Volume II, also covering about 8000 items, will be published early in 1954. This supplement will bring the bibliographical listings up to date for the years 1951–2.

The new supplement is obtainable from U.N. sales agents, price 2*s*.

I.C.I.'s New Plastics Laboratories

The new £300,000 research laboratories of I.C.I.'s Plastic Division at Welwyn Garden City was officially opened on January 5. At the inaugural luncheon the guest speaker was Prof. Sir Cyril Hinshelwood of Oxford, many of whose pupils are now engaged in plastics research. Other academic guests included PROF. F. E. SIMON of Oxford, PROF. F. S. DAINTON of Leeds, PROF. SIR ERIC RIDEAL of London.

The technical press was well represented, the following editors being present: Philip Morgan (*British Plastics*), M. D. Curwen (*Plastics*), E. N. Davis (*Chemical Trade Journal*), Mrs. I. L. Bush (*Chemistry and Industry*), Dr. J. Hoy Robertson (*Industrial Chemist*), W. G. Norris (*Manufacturing Chemist*) and William E. Dick (*Discovery*).

Plastic materials play a very large part in the construction of the new three-storey building. The architects responsible, E. D. Jefferis Matthews and R. S. Poole, have achieved a design which gives exceptional flexibility in the internal arrangements. By means of standardised wall sections, laboratory equipment, plumbing and lighting, it is possible with the minimum of trouble to alter entirely the layout of any one of the three floors. This means that the research worker can at any time rearrange his part of the laboratory to fit in with his individual needs, instead of carrying out his research within the fixed limitations of a standard laboratory. Alterations which would normally necessitate major construction work, in the new laboratories are merely a 'spanner and screwdriver' job.

Basically, the laboratories consist of three unobstructed floors, 176 ft. by 48 ft. Throughout, measurements are based on units of 4 ft. so that all wall panels, piping lengths, bench units, etc., are interchangeable. The main framework is of steel, cladded externally with plastic 'Holoplast' panels. 'Holoplast' is also used for the demountable partition walls and standardised doors, and for the bench tops, though here it is covered with wood veneer. The underbench furniture, cupboards and drawers are faced with 'Formica'. The floors are tiled with a PVC material also used for demountable drainage pipes. Yet another plastic—polythene, an I.C.I. discovery—is used for part of the plumbing, and the lighting fittings are of 'Perspex'.

Other items of interest are the demountable ceiling panels, which are of aluminium and cork filled. The cover strips between these panels are of aluminium-faced plywood made by Wm. Mallinson & Sons (Mfg.) Ltd. Patent Carda windows are fitted throughout the laboratory, and were supplied by Holcon Ltd.

The new laboratory is part of I.C.I.'s programme of expansion of its already large research facilities. Every year the company spends £7,500,000 on research

and development which is carried out at research centres throughout the country. One result has been the introduction of a wide range of new and improved products, many of which have become household words. For example, 'Perspex'—the acrylic plastic—was introduced commercially by I.C.I. Since its early days, when it was used for the transparent glazing of Allied aircraft, it has been developed until it appears now in hundreds of shapes and forms, from surgical instruments and building materials to fancy goods and lighting fittings.

Another outstanding product of I.C.I. research is the important plastic polythene. This material contributed very greatly to the success of another achievement of British research—radar, and today it is widely used for electrical insulation—in television, telephony and all branches of electronics. Polythene has also proved a valuable material for the manufacture of flexible water and chemical piping. Like a large number of other I.C.I. plastics, it has also found its way into the home in many guises.

I.C.I. has already established itself as one of the foremost manufacturers of plastics materials in the world, and in this new home of Research its Plastics Division is now more fully equipped to continue and expand the development of these vital materials.

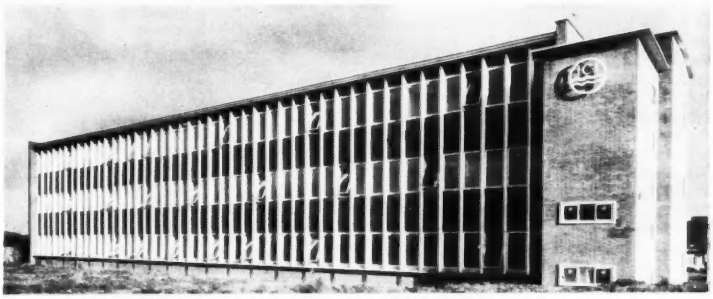
Night Sky in February

The Moon.—New moon occurs on Feb. 3d 15h 55m, U.T., and full moon on Feb. 17d 19h 17m. The following conjunctions with the moon take place:

February				
4d 21h	Mercury in conjunction with the moon		Mercury	4° S.
12d 05h	Jupiter	,,	Jupiter	4° S.
23d 22h	Saturn	,,	Saturn	8° N.
26d 05h	Mars	,,	Mars	4° N.

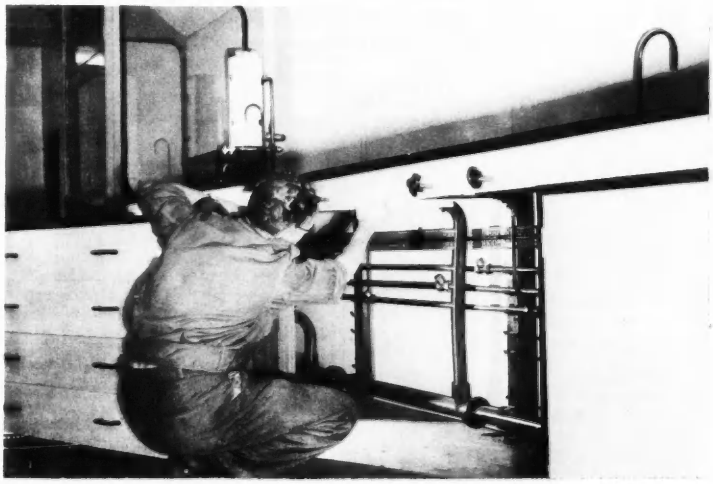
In addition to these conjunctions with the moon, Mars is in conjunction with Antares on Feb. 25d 00h, Mars being 5·4° N.

The Planets.—Mercury is an evening star, setting at 17h 45m, 18h 50m and 17h 55m on Feb. 1, 14 and 28, respectively, in the latter case about 20 minutes after sunset, when it will be invisible. Venus is an evening star, setting at 16h 40m, 17h 20m and 18h 10m on Feb. 1, 14 and 28, respectively, but in all cases this occurs shortly after sunset so that the planet is unfavourably placed for observation. Mars is a morning star, rising at 2h 25m on Feb. 1, 2h 15m on Feb. 14 and 2h at the end of the month. At the beginning of Feb. the planet lies a little S. of γ Librae and its eastward movement is easily recognised; towards the end of the month this has carried it to a position a little N. of α Scorpii (Antares), with which, as has already been pointed out, it is in conjunction on Feb. 25. Jupiter is visible throughout the night, setting in the early morning hours, at 4h 20m, 3h 30m and 2h 35m on Feb. 1, 14 and 28, respectively, and is conspicuous in the constellation Taurus, W. of



The new research laboratories of I.C.I.'s Plastic Division.

Flexibility and adaptability are conspicuous qualities of these laboratories. For example, the partition walls made of Holoplast panels can be taken down and re-erected in an hour or so.



The bench services (gas, water and compressed air transported in copper pipes) are carried in a service gallery and the whole arrangement can be modified at will and with ease. The drip wastes are fabricated in Alkathene and the unit flanged drainage pipes in rigid P.V.C.

the star ζ Tauri. Saturn rises at 0h 50m, 0h and 23h 04m on Feb. 1, 14 and 28, respectively, and is visible during the morning hours a little NW. of α Librae; its stellar magnitude varies from 0·7 to 0·6, which implies that it is slowly increasing in brightness. This is explicable by the fact that its distance from the earth is decreasing: on Feb. 1 this distance is 902 million miles; on Feb. 14 it is 882 million miles, and on Feb. 28 it is 862 million miles. This decrease is due to the earth's orbital motion which carries it towards the direction in which the planet lies. It may be pointed out for the sake of new readers who are not conversant with stellar magnitudes that as the brightness of a heavenly body increases its magnitude is assigned smaller figures, and that a star of magnitude 2 is 2½ times as bright as one of magnitude 3, a star of magnitude 1 is 2½ times as bright as one of magnitude 2, a star of magnitude −1 is 2½ times as bright as one of magnitude 0, and so on.

Launching of the World's First Atomic Submarine

The world's first atomic submarine, the *Nautilus*, built by the U.S. Navy, was scheduled to slide down the slipway at Groton, Connecticut, on January 21 (after this issue of DISCOVERY went to press). The story of the development of this vessel is told in a book by Clay Blair, *The Atomic Submarine and Admiral Rickover* (Rickover is the man who created the atomic submarine project in the face of great opposition), just published in the U.S.A. by Holt.

Sir Stanley Unwin: 50 Years in Publishing

Sir Stanley Unwin has just completed fifty years in publishing, and to mark this jubilee a dinner was given in his honour at the Cutlers' Hall in London. Sir Stanley, who is regarded as the doyen of British publishers, is the head of Allen and Unwin, with whose books our readers will be very familiar, since this firm publishes many scientific books. The scientists whose books are published by Allen and Unwin include the following: C. H. Waddington, Sir Frederic Bartlett, Julian Huxley, C. D. Darlington, K. Mather, J. B. S. Haldane, Sir Edward Bailey, S. J. Shand, John R. Baker, Lancelot Hogben and Sir Arthur Tansley.

Library of Congress: New Scientific Translation Service

The U.S. Library of Congress has set up a service which holds and photo-duplicates translations of scientific items. The initial emphasis will be on translations from Russian scientific journals. Prices for copies of translations will be as follows: Photostats or enlarged microprints, 1.25 dollars for 1–10 pages and 1.75 dollars for 11–15 pages; microfilms, 1 dollar for 1–50 pages. All inquiries should be addressed to the Scientific Translation Center, Science Division, Library of Congress, Washington 25, D.C. Monthly lists of new translations will be available.

A Whale-marking Expedition

Marking of whales is a recognised method for tracing their movements, migrations and distribution. A numbered marker is fired from a 12-bore shot-gun and lodges in or under the blubber. A proportion of these markers are recovered when the whales are captured. Before the war more than 5000 whales were marked in the Antarctic during the 'Discovery Investigations', then organised by the Colonial Office but now transferred to the National Institute of Oceanography. The markers continue to be recovered in small numbers each year; ten have been returned this year, for example.

A new programme of Antarctic whale-marking has just begun. The vessel responsible is the Norwegian whale-catcher *Enern*, and the programme has been planned by Dr. N. A. Mackintosh of the National Institute of Oceanography in consultation with Prof. J. T. Ruud of the Norwegian State Institute for Whale Research. Prof. Ruud is accompanied on this expedition by Mr. R. H. Clarke of the Institute of Oceanography. A Dutch scientist, from the Netherlands Whales Research Group, Mr. Van Utrecht, is also taking part.

The National Institute of Oceanography in England will act as the co-ordinating body and will receive recovered marks with the information on the date, place, species, sex and size of the whale from which each mark is taken. The Norwegian Institute will be supplied with duplicates of all such material, and both organisations will study the conclusions which can be drawn from it. This is a new experiment in international co-operation in research on whales.

Dermatitis due to Penicillin

There has been something of a scare about the dermatitis caused by the handling of penicillin and streptomycin. The urticaria which has been occurring among nurses and midwives is the result of sensitisation of the skin produced by contact with the antibiotic solution. Streptomycin appears to be the worse offender. The Ministry of Health's advice, designed to minimise the risk of this kind of dermatitis, is to expel the air from the hypodermic syringe used for injecting the antibiotic *while the needle is still in the bottle*. The time-honoured technique in which the syringe is charged, removed from the bottle and inverted before expelling the air thereby stands condemned.

The 6-dimensional Atom

The standard space-time description of the atom has been extended to as many as six dimensions in order to explain the large number of particles in the nucleus, not as different forms in themselves, but as different states of one form. The scientist responsible for this development is ABRAHAM PARIS of the Institute for Advanced Study, Princeton, New Jersey. This is reported in the November number of *Industrial and Engineering Chemistry*, which also contains a most important article by PROF. MANSON BENEDICT of M.I.T. entitled "Chemical Engineering Aspects of Nuclear Power". Prof. Benedict, one of the world's outstanding chemical engineers, writes with special authority on this subject, having been a consultant to the U.S. atomic energy project from the beginning.

French Science Editors inspect British Science

A party of French scientific editors visited British research establishments and technological industrial units recently under the auspices of the Foreign Office, acting in conjunction with the Central Office of Information and the DSIR. The party included FERNAND LOT (*Figaro Littéraire*), JEAN PAUL BODET (Editor-in-Chief of *Science et Vie*), LUCIEN J. MEKER (Technical Editor of *L'Usine Nouvelle*), ROGER BERRY (Editor Secretary of *La Technique Moderne*), GERARD LEFEBVRE (Director and Editor of *Science et Avenir*), and PIERRE DE LATIL. Their guide was A. H. WATERFIELD, Scientific Attaché at the British Embassy in Paris.

LETTER TO THE EDITOR

The Efficiency of Electric Space Heating

Professor Kapp* is, of course, perfectly correct in saying that electric heating has an overall efficiency of about 20%, assuming the heating load is taken by the weighted mean of the existing generating stations. May I suggest, however, that he is quite wrong in saying that "extensions of domestic heating will have to be met by the provision of more modern and more efficient generating stations"? New generating stations are needed to meet the extra load of increased industrial mechanisation and to replace obsolete plant. Present increases of the heating load can only be met by keeping obsolete stations at work —there is no other way. Consequently the efficiency will lie between about 20% at off-peak periods down to well below 10% at peak periods.

Even were the new stations to take care of any extra electric heating, it cannot surely be right to replace an existing fire that can burn coal at about 20% efficiency with an electric heater which, if all expenses are taken into account, costs the community well over £100 per kW, when an improved appliance can be bought for about £10 and has an efficiency of over 30%.

Yours faithfully,
OLIVER LYLE

**Prof. R. O. Kapp's letter appeared in* DISCOVERY, *November 1953, p. 360.*

Classified Advertisements

OFFICIAL APPOINTMENTS

ROYAL AIR FORCE

Commissions in the Education Branch

1. Applications are invited from graduates and other qualified teachers with appropriate experience for Short Service Commissions (three, four or five years) in the Education Branch of the Royal Air Force. Requirements are mainly for graduates in Mathematics, Physics or Engineering, or for holders of the Higher National Certificate in Engineering, but there are also vacancies for graduates in English, History and Geography. Graduates with First or Second Class Honours degrees in Science or Engineering subjects may exceptionally be considered for direct appointment to Permanent Commissions. Short Service officers may apply during their service for Permanent Commissions, or for the extension of their Commissions.

2. Basic rate of pay to squadron-leader rank is £319 to £894, plus marriage allowance £338 for officers aged 25 and above (a lower rate of allowance is payable to married officers under 25). Starting point on the scale is determined by academic qualifications, experience and war service in the Armed Forces. Promotion to squadron-leader is by time after satisfactory service and to higher rank by selection. All officers receive either rations in kind or a tax-free allowance in lieu; single officers receive free furnished accommodation.

3. Service in the Royal Air Force Education Branch offers a wide variety of teaching experience, from elementary to advanced levels, with the opportunity for service overseas. Permanent officers are eligible for selection for the Royal Air Force Staff College and for certain post-graduate courses of study related to the service duties.

4. Permanent officers qualify for retired pay based on rank and length of service (e.g. £500 per annum for squadron-leader, £675 for wing-commander, etc.) plus a terminal grant of £1,000. Short Service officers qualify for gratuity at the rate of £100 for each year of service on the Active List. Service on a Short Service Commission in the Education Branch may be treated as contributory service under the Teachers' (Superannuation) Acts and reckoned for increments on the Burnham scale.

5. *Women's Royal Air Force* also has vacancies for Permanent and Short Service Education officers. Conditions of service are similar to those for Royal Air Force Education officers but rates of pay, retired pay and gratuities are somewhat lower.

6. Full details and application forms for all the above appointments may be obtained from the Air Ministry (A.R.1.E.0.3), Kingsway, London, W.C.2.

SCHOLARSHIPS

THE NUFFIELD FOUNDATION

Sociological Scholarships and Bursaries

THE NUFFIELD FOUNDATION, in continuation of its programme for the advancement of sociological studies, is prepared to offer for the academic year 1954–5 a limited number of scholarships and bursaries to enable graduates in academic subjects, other than the social sciences, psychology or economics, to study the social sciences. The Foundation's particular object is to enable men or women, who are already well qualified in other disciplines, particularly the natural sciences or the humanities, to receive a training in, for example, political science, social psychology, anthropology, social statistics and sociology generally (but not economics) so as to enable them in due course to undertake research or teaching in the United Kingdom in those subjects. *The scholarships*, which are the senior awards, are intended for persons who have already undertaken some postgraduate work in their own subject. *The bursaries* are intended to enable those who have recently graduated to take a course of training in sociological subjects. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1954 must be received, before May 1, 1954, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN
Director of the Nuffield Foundation

THE NUFFIELD FOUNDATION

Biological Scholarships and Bursaries

THE NUFFIELD FOUNDATION, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1954–5 a limited number of scholarships and bursaries to enable persons who have graduated in physics, chemistry, mathematics or engineering, but who have had no training in a biological subject, to receive such training in biology as will enable them to undertake research and teaching in the United Kingdom in the biological sciences. *The scholarships*, which are senior awards, are intended for persons who have already undertaken some postgraduate research in their own subject. *The bursaries* are intended to enable those who have recently graduated to complete a course of training in biological subjects including, if considered necessary, a full honours degree course in biology. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1954 must be received, before April 1, 1954, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

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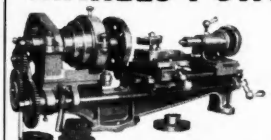

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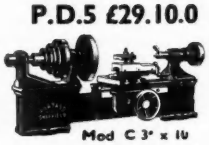

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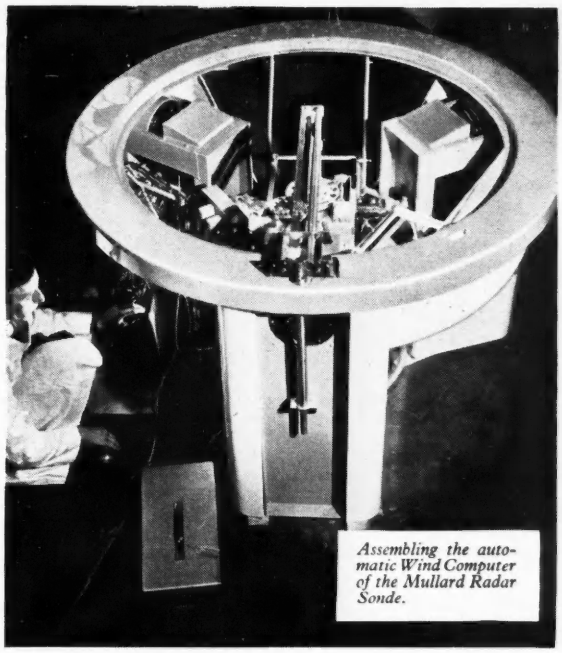

Assembling the automatic Wind Computer of the Mullard Radar Sonde.

PROGRESS IN ELECTRONICS

THE rapid growth of air traffic throughout the world and the introduction of high speed aircraft flying at great heights have multiplied the problems of the meteorologist. The methods of forecasting weather conditions which were adequate ten years ago cannot provide the detailed and accurate data which are required today.

A new technique for weather forecasting has, however, now been developed. By employing an equipment known as the Radar Sonde, the complex conditions in the upper atmosphere can be accurately measured and recorded.

A small balloon carries a miniature radio and meteorological station up to a height of 100,000 ft. and is borne by the wind to distances exceeding 100 miles. Throughout its flight the balloon is continuously interrogated by a powerful radar transmitter, and the answers are transmitted back by return.

As the information is received at the ground station it is decoded, computed and recorded to give a detailed picture of wind speed and direction, and of temperature, pressure and humidity.

The Radar Sonde has been designed and built by the Mullard Research Laboratories in co-operation with the Ministry of Supply and the Meteorological Office.

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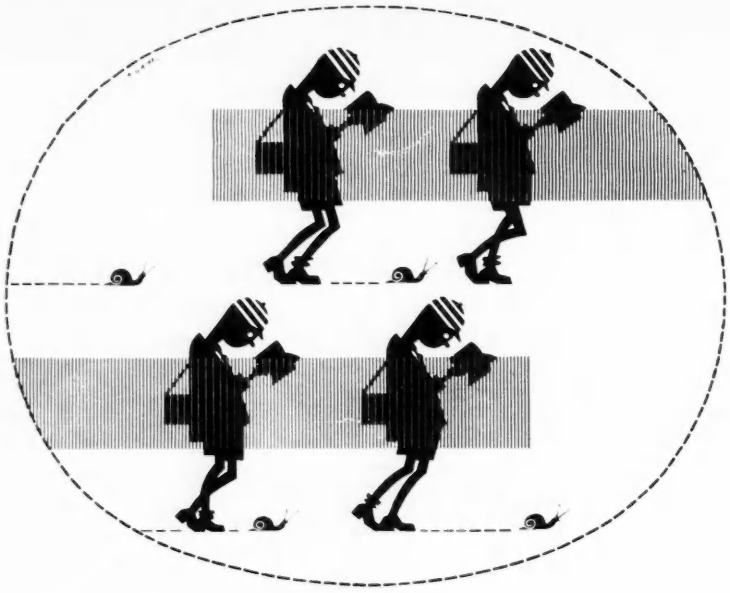

Slow Motion

"CREEP" IS NOT A WORD normally associated with jet propulsion. Yet metallic creep—the slow stretching of a metal under stress at high temperature—is a major problem in jet engine design, and it enters increasingly into many branches of engineering. Creep can increase the diameter of hot steam pipes under the constant pressure from inside. The fast-spinning rotor of an electricity generator may, if it becomes hot enough, distort under the creep caused by centrifugal force. Unless this has been taken into account in designing the generator, its rotor may ultimately foul the generator's shell. Even at ordinary temperatures, lead creeps at quite low stresses and unless appropriate steps are taken, lead sheeting can flow slowly down a roof.

To provide much-needed information on creep, I.C.I. have built a special testing station at Witton, near Birmingham. At this I.C.I. station, the latest techniques are being used to record the changes in metals under stre at various temperatures and over very long periods. Th tests are carried out on sixty machines. Metal test-piec clamped between steel jaws are loaded by a force of up t 5 tons to the square inch, while the test temperatur which may be as high as 1000°C, can be maintained fo years on end. Special instruments can detect lengt increases as small as one fifty-thousandth of an inch in th test-pieces. Air conditioning keeps the windowless build ing at a steady 67°F. night and day. Humidity is con trolled. To minimise vibration, the testing machines are mounted in concrete rafts independent of the building foundations. Tests carried out in this I.C.I. research station are providing invaluable information on metallic creep, needed by the designers and engineers who are building I.C.I.'s great new plants and factories, and by the users of the wrought non-ferrous metals marketed by I.C.I.

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